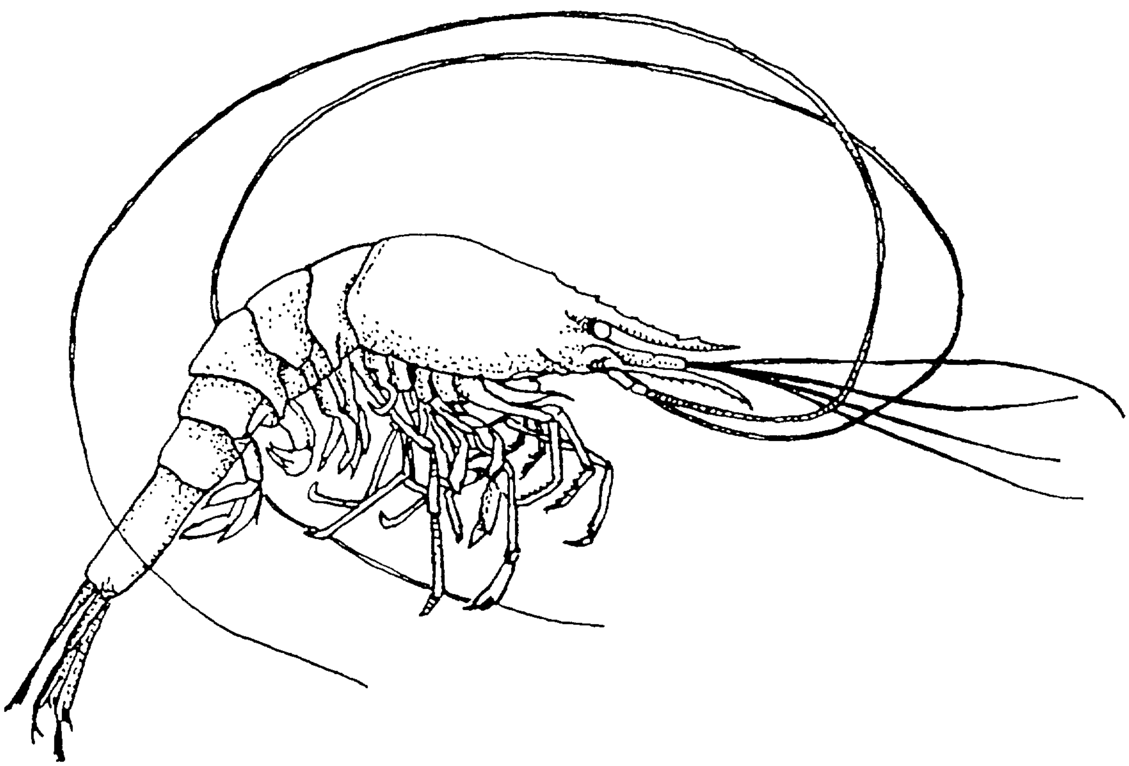
Alabama Cave Shrimp

(Palaemonias alabamae)

Recovery Plan



U.S. Fish and Wildlife Service
Southeast Region
Atlanta, Georgia

ALABAMA CAVE SHRIMP

Palaemonias alabamae

RECOVERY PLAN

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for

Southeast Region
U.S. Fish and Wildlife Service
Atlanta, Georgia

Approved: H Dale Hall
Acting Regional Director

Date: 9/4/97

Recovery plans delineate reasonable actions that are believed to be required to recover and/or protect listed species. Plans are prepared by the U.S. Fish and Wildlife Service, sometimes with the assistance of recovery teams, contractors, State agencies, and others. Objectives will only be attained and funds expended contingent upon appropriations, priorities, and other budgetary constraints. Recovery plans do not necessarily represent the views or the official positions or approvals of any individuals or agencies, other than the U.S. Fish and Wildlife Service, involved in the plan formulation. They represent the official position of the U.S. Fish and Wildlife Service only after they have been signed by the Regional Director or Director as approved. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery tasks.

By approving this document, the Regional Director certified that the data used in its development represents the best scientific and commercial information available at the time it was written. Copies of all documents reviewed in the development of the plan are available in the administrative record, located at the Jackson, Mississippi, Field Office.

Acknowledgment:

The U.S. Fish and Wildlife Service thanks Sam Beibers of Beibers Creative Arts for the cover sketch.

Literature citations should read as follows:

U.S. Fish and Wildlife Service. 1997. Recovery Plan for the Alabama cave shrimp (*Palaemonias alabamae*). Atlanta, Georgia. 59 pp.

Additional copies of this plan may be purchased from:

Fish and Wildlife Reference Service
5430 Grosvenor Lane, Suite 110
Bethesda, Maryland 20814

Phone: 301/492-6403 or
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EXECUTIVE SUMMARY

Current Status: The Alabama cave shrimp (*Palaemonias alabamae*) is listed as endangered. The shrimp has been found in three groundwater basins (five caves) near the city of Huntsville, Madison County, Alabama. Available information indicates the overall population may be declining, and the shrimp is apparently extirpated from Shelta Cave, the type locality, leaving two extant populations. The only other known species of *Palaemonias* is the endangered Kentucky cave shrimp (*P. ganteri*).

Habitat Requirements and Limiting Factors: The Alabama cave shrimp occurs in pools in a cave environment. In caves with high flows, the shrimp must have access through cave windows to calmer groundwater habitat. Nonpoint source groundwater contamination represents the major threat to this cave-dwelling species. Other threats include destruction of habitat, collecting, and predation.

Recovery Objective: Reclassification to threatened.

Recovery Criteria: Criteria for reclassification are:

1. Identification and protection of reproductively viable populations of Alabama cave shrimp in five groundwater basins (or aquifers).
2. Reproductive viability, defined as reproducing populations which are stable or increasing in size, should be demonstrated for all five populations for a 20-year period.

Actions Needed:

1. Protect Alabama cave shrimp populations and their groundwater habitat.
2. Develop technical information and educational material essential for cave and recharge area stewardship.
3. Monitor Alabama cave shrimp populations.
4. Conduct life history and other needed research.
5. Continue searching for additional populations.
6. Modify or replace the gated entrance to Shelta Cave.
7. Assess suitability of re-introduction of Alabama cave shrimp into Shelta Cave.

Total Estimated Cost of Recovery: Implementation of the recovery tasks for which cost estimates have been made total $182,000.

Date of Recovery: Unable to determine at this time.

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I. INTRODUCTION

BACKGROUND

The Alabama cave shrimp, *Palaemonias alabamae* Smalley, is an albinistic troglobitic (cave-dwelling) shrimp known from five caves (three cave systems or three groundwater basins) in Madison County, Alabama (Figure 1). A member of the shrimp family Atyidae, it is one of two atyid shrimps known from the eastern United States. The only other known species of *Palaemonias* is the endangered Kentucky cave shrimp (*P. ganteri*) from Mammoth Cave National Park.

The Alabama cave shrimp was first collected by Poulson in 1958 (Cooper 1975). Smalley (1961) described the species from a series of 20 shrimp collected from Shelta Cave in northwest, Madison County, Alabama. Other known populations are found in Bobcat, Hering, Glover, and Brazelton caves in Madison County, Alabama (McGregor *et al.* 1994, Rheams *et al.* 1994). Shelta and Bobcat caves were the only known caves inhabited by the shrimp until its discovery in Hering and Glover caves in 1991 and Brazelton Cave in 1994. These new locations extend the range for this species approximately 20 kilometers (km) (12 miles) east-southeast across the Flint River and the Huntsville, Green, and Monte Sano Mountains (McGregor *et al.* 1994).

The Alabama cave shrimp was first proposed for protection in 1977. At the time of the proposal, the Alabama cave shrimp had not been seen in Shelta Cave since 1973 and the only remaining population occurred in Bobcat Cave. The proposal was withdrawn in 1979 for administrative reasons stemming from new listing requirements of the 1978 amendments to the Endangered Species Act of 1973. The re-proposal was published on November 19, 1987. On September 7, 1988, the U. S. Fish and Wildlife Service (Service) published a final rule in the *Federal Register* (U.S. Fish and Wildlife Service 1988) determining the Alabama cave shrimp (*Palaemonias alabamae*) to be an endangered species under the Endangered Species Act of 1973, as amended.

DESCRIPTION

The Alabama cave shrimp is a small, colorless, translucent, freshwater decapod crustacean measuring up to 30 millimeters (1.2 inches) in total length (Figure 2). It is distinguished from other shrimp by the almost equal length of the first and second pereopods (legs), the presence of antennal, supraorbital and pterygostomial spines on the carapace (shell), and by rudimentary eye stalks which are unfaceted and without pigment. This species differs from its closest relative, the endangered Kentucky cave shrimp

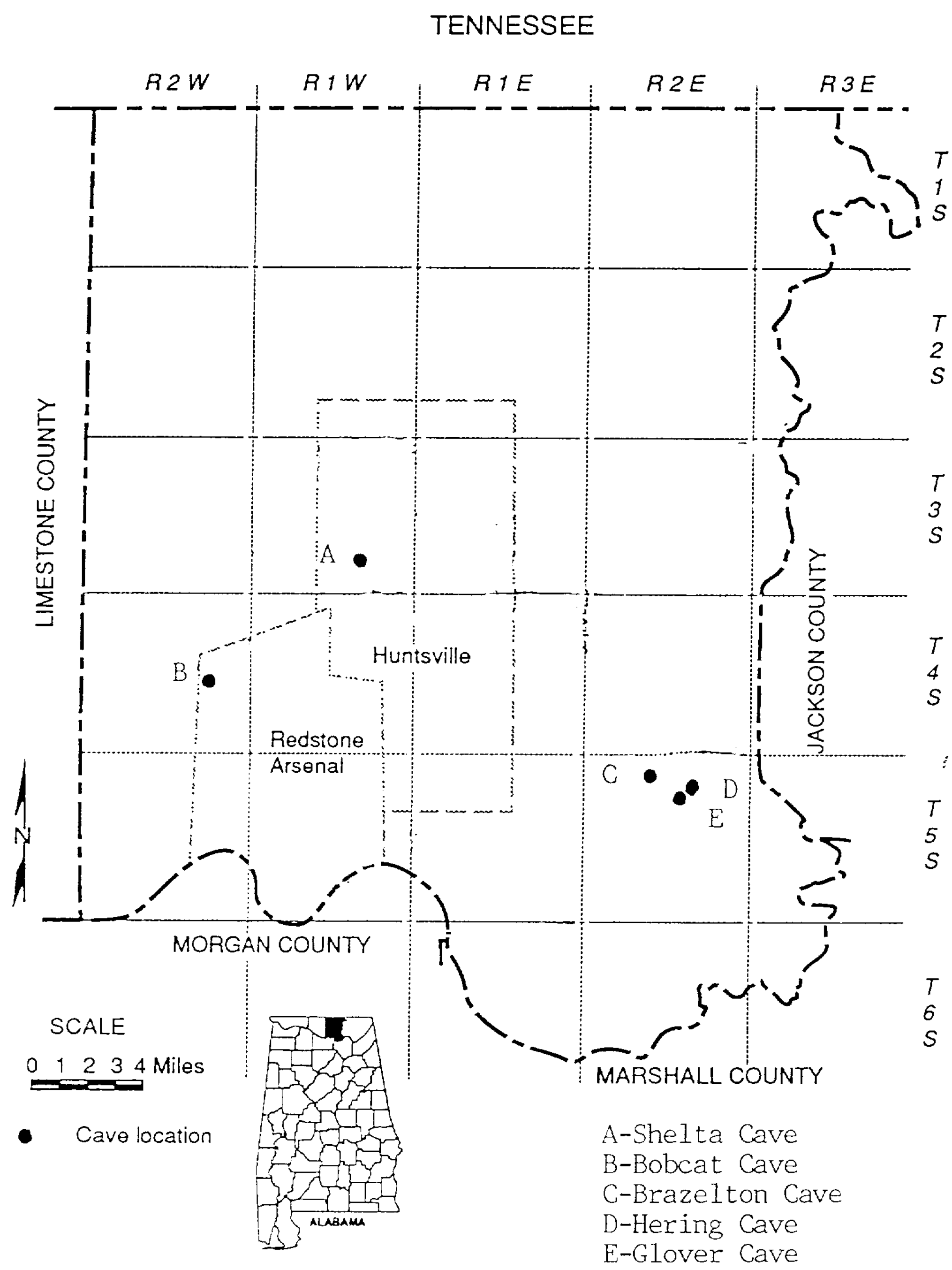

Figure 1. Location of caves known for Alabama cave shrimp (Palaemonias alabamae) in Madison County, Alabama (figure adapted from Rheams et al. 1994).

(*Palaemonias ganteri*), by its smaller size, shorter rostrum (flattened frontal portion of head), absence of ventral rostral spines, fewer dorsal rostral spines, and other morphological characters (Smalley 1961). Photographs of the Alabama cave shrimp appear in Rheams *et al.* 1992 and Rheams *et al.* 1994.

DISTRIBUTION

The Alabama cave shrimp has been found in five caves in Madison County, Alabama. The type locality, Shelta Cave, is within the northwest limits of Huntsville, Alabama, and is owned by the National Speleological Society (NSS). Bobcat Cave is located approximately 13 km (8 miles) southwest of Shelta Cave on Redstone Arsenal, a U.S. Army installation. Brazelton, Glover, and Hering caves are located approximately 20 km (12 miles) southeast of Huntsville and are privately owned. These three caves are hydrologically connected and should be considered one system. A sighting of three cave shrimp was reported (December 12, 1993) from a cave in western Jackson County about 24 km (15 miles) northeast of Hering Cave (McGregor *et al.* 1994), but this sighting has not been verified as of this recovery plan date (1997).

Figure 2. Alabama cave shrimp, *Palaemonias alabamae* Smalley, identified in Hering Cave, Madison County, Alabama. (Photograph by Dave Dieter, Huntsville Times, December 1991).

HABITAT/ECOSYSTEM

Little is known about the habitat requirements of the Alabama cave shrimp, other than it occurs in silt-bottomed pools in a cave environment. Our limited knowledge of the Alabama cave shrimp and its habitat is based on observations primarily from Shelta Cave and secondarily from Bobcat Cave. Only a few observations have been made of the shrimp inhabiting Glover, Hering, and Brazelton caves (see Appendix A).

Cave geology and hydrology

Shelta and Bobcat caves were formed in the Warsaw Unit of the Tuscumbia Limestone of Mississippian Age. The Warsaw is a thick-bedded, coarsely crystalline limestone which, together with the St. Louis Unit, comprises the extensive Tuscumbia Limestone (Hobbs and Bagley 1989). Glover, Hering, and Brazelton caves formed in the Monteagle Limestone of Upper Mississippian Age.

Solution caves, springs, and sinkholes are dominant hydrogeological features of Madison County, Alabama. Groundwater in Tuscumbia and Monteagle Limestone occurs within interconnected openings, cracks, and crevices. Rainfall and occasional snowfall recharge or restore the groundwater in this area. Heavy precipitation can cause a significant rise in groundwater level and cause flooding of caves (see Moser and Rheams 1992 and McGregor *et al.* 1994 for additional discussion).

The land surface area that feeds the groundwater basin, or aquifer, is called the recharge area. Land use activities in cave recharge areas directly affect the quality of groundwater that enters the cave (Hobbs 1992). Shelta Cave is located within the city limits of Huntsville (population 360,000 plus) and Bobcat Cave is just outside the city limits while the other three caves are located on the valley floor of Keel Mountain. Land use in the area of caves containing Alabama cave shrimp can be classified into five categories: urban, industrial/suburban, forest/suburban, agriculture, and forest (Moser and Rheams 1992).

Shelta Cave

Shelta Cave is located in an urbanized area of Huntsville and the cave entrances are owned by NSS and gated to control access. Shelta Cave consists of three large rooms with smaller alcoves. Water is present in all of the cave areas during wet periods. However, water levels fluctuate as much as 6.7 meters (m) or 22 feet leaving some areas of the cave seasonally dry (Cooper 1975). Miller Hall, the westernmost chamber, contains the only permanent body of water, West

Lake, and the only permanent stream, West Creek, in Shelta Cave. West Creek is shallow (15-20 centimeters or 6-8 inches deep during low flow), has few riffles, flows to the southeast, and sinks approximately 60 m or 197 feet from its source (Hobbs and Bagley 1989). High flows in the cave occur during winter and spring months of heavy precipitation. Recharge area studies have been completed for Shelta Cave (Moser and Rheams 1992, Rheams *et al.* 1992, Rheams *et al.* 1994). The recharge area surrounding Shelta Cave encompasses approximately 88.4 square kilometers or 34 square miles and is privately owned. Land use in the recharge area is urban or industrial/suburban.

Bobcat Cave

Bobcat Cave is found on the Redstone Arsenal, a U.S. Army installation and access is restricted. Bobcat Cave consists of one large room with a low ceiling and several alcoves and passages. Water levels fluctuate dramatically throughout the year, and at high levels may block the entrance passage (F. Bagley, U.S. Fish and Wildlife Service, pers. comm., 1990). During summer and fall low water levels, the cave pool retreats through the cave floor to the aquifer below. Initial recharge surveys of Bobcat Cave have been completed (Moser and Rheams 1992, Rheams *et al.* 1992, McGregor *et al.* 1994). On the Arsenal, the land immediately surrounding the cave is in pasture and is leased for cattle grazing. Redstone Arsenal airfield is located about 1.6 kilometers or 1 mile east of Bobcat Cave. Surrounding the Arsenal, the land use in the recharge area is suburban, forested, pastured, or in agriculture. The suburban/urban areas are expanding and becoming more densely populated.

Hering Cave

Hering Cave has a large tunnel-like stream passage and a large boulder-strewn outflow channel which exits from the cave entrance. Stream depth varies from a few centimeters (a few inches) to approximately 2.4 m or 8 feet deep, with the cave flooding during rain storms (McGregor *et al.* 1994).

Glover Cave

Glover Cave contains a tunnel stream passage with very few side passages and three standing pools of deep water. Water flowing from Hering Cave enters Glover Cave through two (entrance one and sinkhole two) of the five cave entrances (McGregor *et al.* 1994). Glover Cave can contain swiftly flowing water during the wet, winter and spring seasons.

Brazelton Cave

Brazelton Cave is a solution tunnel with numerous permanent pools of water and seasonal stream flow. This stream is hydrologically connected to the stream that flows in Glover Cave (McGregor *et al.* 1994). Brazelton Cave completely floods during intense rain storms and seasonally in the winter and spring.

Land use surrounding the three privately owned caves (Hering, Glover, and Brazelton) is primarily rural with agriculture and forested areas, but land is presently being cleared for suburban development. These caves are hydrologically connected both above ground and underground and can be considered to be a cave complex or system; therefore, any changes in surrounding land use may affect the surface water and groundwater of all three caves. Except for some limited dye tracing work (W. Campbell, Univ. Ala. Huntsville, pers. comm., 1997), no recharge surveys have been done for this cave system.

See Rheams *et al.* 1994 for further descriptions, photographs, and survey maps of the five caves known for the Alabama cave shrimp.

Cave ecosystem

Cave environments are relatively simple ecosystems characterized by moderate stable temperatures and a lack of visible light (Cooper 1975). Because of the lack of light, food sources are limited. The only autotrophs (plant-like organisms) present are chemosynthetic (like some bacteria). The resident aquatic fauna are dependent on plant and animal material washed into the cave.

The base of the food web in the five shrimp caves appears to be organic material, detritus, and other food items carried in by flowing water. Cooper (1975) observed Alabama cave shrimp ingesting silt and other bottom debris in shallow pools of Shelta Cave. Cooper also observed shrimp apparently feeding on suspended organic particles on the surface of the water. During a study in Mammoth Cave, Kentucky, Leithauser (1988) found that a complex assemblage of bacteria, protozoans, and minute crustaceans fed on detritus particles in cave stream sediments, and observed that the Kentucky cave shrimp fed on these organisms by non-selective grazing.

Until the early 1970's, a maternity colony of the endangered gray bat, *Myotis grisescens*, provided energy in the form of guano to the aquatic system of Shelta Cave (Hobbs and Bagley 1989). The bat colony abandoned the site, possibly as a result of the installation of an entrance gate, development around the cave, or a combination of these and other factors. The entrance gate was modified in 1981 in an attempt to accommodate gray bats but based on more recent studies, additional modifications or a different style gate are needed to promote recolonization. A few gray bats and other bat species are still observed flying around Shelta Cave entrances (French 1988). Loss of the Shelta Cave gray bat colony caused a decrease in the organic input to the aquatic community of the cave, and may have resulted in, or contributed to, a corresponding decrease in the populations of other cave species (Cooper 1975, Hobbs and Bagley 1989). No bat colonies are known to have occurred in Bobcat, Brazelton, Glover, or Hering caves but individual bats have been seen hibernating or flying in Bobcat, Glover, and Hering caves (see Appendix A).

LIFE HISTORY/OBSERVATIONS

Almost nothing was known about the life history of the Alabama cave shrimp until Cooper's (1975) studies in Shelta Cave. Cooper (1975) observed gravid shrimp (females with oocytes or attached ova) during every month between July and January. The number of eggs carried ranged from 4 to 30. Cooper believed the eggs matured during the autumn months and were ready to hatch in the winter. Based on Cooper's studies and on shrimp length measurements in Bobcat and Brazelton caves, McGregor *et al.* (1994) concluded that shrimp require at least one growing season to reach sexual maturity. Larval development of the Alabama cave shrimp is undescribed.

Cooper (1975) estimated sex ratios of the Alabama cave shrimp to approach a 1:1 ratio. He also reported sexual dimorphism in the species with females averaging 1.2 millimeters (0.05 inches) longer than males in total length, and male rostrum length averaging 4.2 percent longer than females. Longevity is unknown; however, results from aquaria studies on the closely related Kentucky cave shrimp indicated an estimated life span of 10 to 15 years for that species (Leithauser 1988).

Cave invertebrate population numbers are, in general, much smaller than surface populations due to the limited resources of the habitat. Leitheuser (1988) reported population densities of the Kentucky cave shrimp, based on length of passage, to be highly variable ranging from 0.002 to 0.200 shrimp per foot of cave. The population density of the Alabama cave shrimp is unknown.

The inability to locate and observe cave shrimp during any particular visitation does not imply the absence of the shrimp from a cave system. Cave shrimp are small and nearly transparent and are, therefore, difficult to observe even under optimum conditions. In addition, small aquatic organisms can hide in inaccessible cracks, crevices, or windows containing water. A cave "window" is any feature in the cave floor containing water that is hydrologically connected to deeper groundwater basins. The use of windows by Alabama cave shrimp was documented by Cooper (1975) and McGregor *et al.*(1994). They observed shrimp and other aquatic cave animals near windows, swimming in and out of windows, or using windows to escape when disturbed.

Shelta Cave Observations

Cooper noted occurrence of the Alabama cave shrimp in Shelta Cave to be seasonal (Cooper 1975). Cave shrimp were never collected during the months of March through June, and only a single specimen was observed during February. Typically, the winter and spring months receive more precipitation than other months. Difficulties in finding shrimp appear to coincide with high water levels as aquatic habitat expands and disperses the shrimp. During low water, the aquatic habitat shrinks and forces shrimp into the remaining available habitat thereby increasing the chances of finding them. Cooper found more shrimp in West Lake of Shelta Cave during low water. The greatest number of shrimp observed by Cooper occurred in November (24 shrimp) and December (25 shrimp) 1968.

In 1985, a NSS committee initiated a 2-year biological monitoring study in Shelta Cave with emphasis on aquatic organisms (Hobbs and Bagley 1989). This study noted a reduction in all cave faunal elements since Cooper's study, and no Alabama cave shrimp were found. During December 1988, a 6-day search of Shelta Cave by a Service biologist and NSS members also failed to locate the Alabama cave shrimp in Shelta Cave (Hobbs and Bagley 1989). Shrimp surveys in Shelta Cave during 1990-1993 were also unsuccessful in relocating the species (Moser and Rheams 1992, Rheams *et al.* 1992, McGregor *et al.* 1994). No Alabama cave shrimp have been observed in Shelta Cave since 1973, and surveys (Hobbs and Bagley 1989, McGregor *et al.* 1994) indicate that the shrimp has apparently been extirpated.

Bobcat Cave Observations

The Alabama cave shrimp was first observed in Bobcat Cave by Bill Torode in 1973 (B. Torode, NSS, pers. comm., 1990) and reported by Cooper and Cooper (1974). At least one cave shrimp was observed in Bobcat Cave by a Service biologist and NSS members during the spring of 1986 (F. Bagley, *in litt.*). The cave was flooded and two sightings of a shrimp were made along the pool edge near the cave entrance. Two cave shrimp were observed stranded in a mud puddle on the cave floor by a Service biologist and NSS members during the summer of 1986 (F. Bagley, *in litt.*); the water level was below the floor of the cave. Bobcat Cave was again searched at flood stage during the winter of 1988 without finding the Alabama cave shrimp (F. Bagley, *in litt.*).

Additional cave shrimp sightings and observations have occurred in Bobcat Cave since Cooper's work in the 1970's and Bagley's work in the 1980's. During a more recent study, 30 weekly visits were made to Bobcat Cave in which a total of 172 shrimp were observed (Rheams *et al.* 1992). No shrimp were seen in 16 of those visits, whereas a study high of 51 individual shrimp was observed on July 22, 1991. In another Bobcat Cave study, 128 shrimp were observed during 33 weekly visits (McGregor *et al.* 1994). The number of shrimp recorded ranged from a low of zero on nine visits to a high of 13 on October 21, 1992.

Rheams *et al.* (1992) observed at least 10 gravid females in Bobcat Cave on the following dates: one in May 1992, an undetermined number in July 1991, three in August 1991, and four in October 1991. From a total of 128 shrimp observed in Bobcat Cave, only five gravid female cave shrimp were noted by McGregor *et al.* (1994): two in October 1992 and three in July 1993.

Glover/Hering/Brazelton Observations

Due to the fairly recent discovery of Alabama cave shrimp in the hydrologically connected Glover, Hering, and Brazelton Cave System, few data have been collected on this population. In October 1991, four shrimp were found in a shallow, isolated pool in Glover Cave (Rheams *et al.* 1992). On October 30, 1991, Rheams *et al.*(1992) also found two shrimp (one gravid female) in Hering Cave. Seven days later, on November 6, two shrimp were observed again in Hering Cave; one was a gravid female which was not collected but the other, the non-gravid shrimp, was taken for species documentation. In September 1993, three shrimp were also seen in a single pool in Hering Cave (McGregor *et al.* 1994). An unconfirmed sighting of very small shrimp in a small pool in an upper level of Brazelton Cave was reported by NSS cavers in November 1991 (Rheams *et al.* 1992). Confirmation of the Alabama cave shrimp in Brazelton Cave finally occurred in November 1994, when eight shrimp were observed and five were measured (McGregor *et al.* 1994).

REASONS FOR LISTING

The Alabama cave shrimp was listed because of the apparent extirpation of one of only two known populations (at the time of listing) and the vulnerability of the surviving population to ground water contamination. Alabama cave shrimp are vulnerable to the following factors: (1) destruction of habitat; (2) collecting; and (3) predation.

Habitat Destruction

Destruction of habitat includes physical alterations to a cave, such as dumping trash into a cave or sinkhole, or closing off cave entrances or sinkholes; alteration of drainage and hydrologic patterns; lowered groundwater levels; and groundwater degradation or contamination by toxins, nutrients, and sewage.

The cave systems containing Alabama cave shrimp are found in karst formations. Karst is a limestone region characterized by solution features such as sinks, springs, underground streams, tunnels, and caverns. The susceptibility of karst to groundwater pollution has been well documented (LeGrand 1973, Dilamarter and Csallany 1977, Vandike 1985, Aley and Aley 1987). Surface pollutants can easily and rapidly enter the subsurface aquifer, particularly during storm events. Urbanization of areas surrounding Shelta and Bobcat Caves, and development in the recharge area of the Glover, Hering, Brazelton system may cause contamination of the aquifers containing Alabama cave shrimp. Groundwater contamination may result from sewage leakage, industrial contaminants, road and highway runoff, toxic spills, pesticides, and siltation.

Urbanization has also increased water demand in Huntsville. The city has experienced severe water shortages during the past few years due to increased demand and drought (Huntsville Times, 21 June 1989, *in litt.*). In response, the city drilled and brought on line the Drake well. Capable of pumping up to 7,570 liters (2,000 gallons) per minute, this well is located less than 1 km or one half of a mile from Bobcat Cave. Increased water consumption has the potential to affect Bobcat and Shelta Cave aquifers by lowering groundwater levels and reducing the amount of available Alabama cave shrimp habitat.

Habitat degradation has occurred in Shelta Cave from unknown causes. Water samples taken in Shelta Cave in 1987 indicated that the aquifer had become contaminated by cadmium, heptachlor epoxide, and dieldrin (J. French, *in litt.* 1987). Anomalous levels of cadmium, almost five times the drinking water standards, are possibly of industrial or municipal origin. Both heptachlor epoxide and dieldrin can originate from the degradation of chemicals used for termite control. The two pesticides are extremely toxic to aquatic life and, along with cadmium, present a danger of bioaccumulation in the food web. Since aquatic troglobites tend to be long-lived and may store rather than rid themselves of pollutants such as these, even low levels can be of concern (Dickson *et al.* 1979, Bosnak and Morgan 1981, Hobbs 1992).

Comparison of aquatic surveys of Shelta Cave conducted during 1968-1975, 1985-1987, and 1988, reveal a decline in all aquatic organisms monitored (Hobbs and Bagley 1989). Whether this decline is due to water quality degradation, nutrient loss due to abandonment of the cave by bats, or a combination of these and/or unknown factors, remains to be determined.

Suburbanization is starting to occur near Glover, Hering, and Brazelton caves. Forested land is being cleared for new homes on Keel Mountain. Septic tank systems are needed for each new home since there presently is no sewer system in place. The shrimp found in Glover, Hering, and Brazelton caves will be in danger of surface water and groundwater contamination from sewage leakage, lawn fertilizers, pesticides, and increased surface runoff from residential development in the near future (Campbell *et al.* 1995, S. McGregor, pers. comm., 1996, R. Blackwood, NSS, pers. comm., 1997).

Collecting

Since the cave shrimp population in each of these caves is so low that they are rarely seen, the removal of any shrimp by collectors may affect the ability of the species to reproduce. Other cave species are known to have extremely low reproductive rates when compared to closely related surface species (Cooper 1975). If the same is true for the Alabama cave shrimp, declining population numbers compounded by low reproductive rates will significantly affect the species' ability to recover. Glover, Hering, and Brazelton caves are located on private property and are easily accessible to cavers and trespassers. However, unauthorized collecting of cave shrimp from Shelta and Bobcat Caves is not likely to occur due to the protection afforded by the landowners. The entrances to Shelta Cave are owned by the NSS and are gated to control access. Bobcat Cave is located on Redstone Arsenal, a U.S. Army installation, and access is restricted.

Predation

Predation may impact cave shrimp populations. Cooper and Cooper (1974) observed a southern cavefish, *Typhlichthys subterraneus*, regurgitating a cave shrimp in Shelta Cave. Other potential predators in this cave include the Tennessee cave salamander, *Gyrinophilus palleucus*, and two troglobitic crayfishes. Potential predators that have been observed in Bobcat, Brazelton, Glover, and Hering caves are the southern cavefish, troglobitic crayfish, unidentified salamanders, Tennessee cave salamander, bullfrogs, and raccoons (Rheams *et al.* 1992, McGregor *et al.* 1994). Predation by naturally occurring predators is a normal aspect of the population dynamics of a species. However, the effect of predation on a declining troglobitic species with an apparently low reproductive potential would be more significant than if the population were stable.

CONSERVATION MEASURES

Entrances to both Shelta and Bobcat caves are protected by the owners and public access is controlled. The NSS has produced a management plan for Shelta Cave with the purpose of protecting and recovering the biological resources of the cave (Hobbs and Bagley 1989). However, this plan has not been approved or implemented by the NSS. The Environmental Protection Agency (EPA) has restricted the use of heptachlor epoxide and has banned all uses of dieldrin. The Geological Survey of Alabama (GSA), Department of Army (DOA), and the U.S. Fish and Wildlife Service have conducted hydrogeologic studies of Shelta and Bobcat cave aquifers (Moser and Rheams 1992, McGregor *et al.* 1994, Rheams *et al.* 1994). A Huntsville school teacher and his students, along with members of the Huntsville Grotto have recently started conducting water quality measurements and monitoring cave species, including bats, in Shelta Cave (R. Blackwood, pers. comm., 1997). The GSA has searched and inventoried features and fauna of caves in Madison, Marshall, Morgan, and Jackson counties (Moser and Rheams 1992, McGregor *et al.* 1994, Rheams *et al.* 1994). In cooperation with the DOA, the University of Alabama in Huntsville (UOAH) has completed hydrologic modeling for Bobcat Cave (Campbell *et al.* 1995) and is presently developing a pollution model for the cave. Also in cooperation with DOA, the GSA is currently conducting a water quality and risk assessment study of Bobcat Cave. In a separate effort not directly related to this recovery plan, the Alabama Department of Environmental Management and UOAH initiated a groundwater protection education project, funded by Clean Water Act Section 319, for Madison County (V. Cox, UOAH, pers. comm., 1977).

II. RECOVERY

A. RECOVERY OBJECTIVE

The objective of this plan is to ensure the protection and viability of the Alabama cave shrimp in order to reclassify the shrimp from endangered to threatened status. The quality and condition of groundwater in cave shrimp karst habitats is intimately tied to land use practices within cave recharge areas. Therefore, protection of the Alabama cave shrimp is entirely dependent on proper stewardship of surface land and water. Surface activities that have the potential to contribute to the degradation of groundwater and cave habitats are best managed at the individual landowner and community level. Protection of cave shrimp populations is achievable by informing and educating residents within recharge areas of groundwater values, threats, and stewardship responsibilities; and by recruiting, involving, and assisting them in voluntary stewardship efforts.

Reclassification

Reclassification to threatened status will be considered when one reproducing population has been identified and protected in five groundwater basins (for a total of five populations) and the populations remain viable in these basins, as evidenced by monitoring, over a 20-year period. It is unlikely that reclassification can be achieved without efforts by all involved parties to protect groundwater.

B. RECOVERY NARRATIVE OUTLINE

This narrative outline provides a detailed explanation of the recovery tasks and actions believed necessary to recover this species.

1. Protect Alabama cave shrimp populations and their habitat. Due to the nature of karst habitats and their vulnerability to contamination by surface activities, protection of the Alabama cave shrimp is dependent on the cooperation and stewardship of recharge areas by landowners and local inhabitants. Protection of recharge areas is essential to prevent extinction of the species. Numerous local, State, and Federal organizations and agencies are actively involved in encouraging land and water stewardship in Madison County and northern Alabama. The Service should support and assist existing private and public stewardship efforts with emphasis on cave shrimp recharge areas.

1.1 Encourage and assist in the development of management plans for caves and recharge areas inhabited by the Alabama cave shrimp. Management plans draw attention to the presence and vulnerability of the cave shrimp and its habitat, serve as educational documents, provide an avenue for dialogue, and promote planning, Best Management Practices (BMPs) and stewardship. Management plans should provide maps of the recharge area; identify primary land use activities within the recharge area (e.g., agriculture, private homes, industry, etc.) and their potential effects on groundwater and the shrimp; summarize basic essential stewardship measures and responsibilities (e.g., cave gating, sediment control, waste disposal, BMPs, etc.); and list partners and contacts for assistance, information, and emergency response. Recharge area management plans should be developed with review and input by all stakeholders and potential partners within the recharge area.

1.1.1 Develop and implement Shelta Cave Management Plan. The NSS developed a management plan for Shelta Cave in 1989, however, the plan was never approved or fully implemented. The Service should encourage the NSS to reexamine this plan; provide for review and input by residential, commercial, and other stakeholders and potential partners within the recharge area; and revise the plan as needed. The Service and other governmental agencies should provide technical assistance as needed.

1.1.2 Develop and implement Bobcat Cave Management Plan. The Department of the Army (DOA), Redstone Arsenal, has funded several studies to delineate the Bobcat Cave recharge area and model its hydrology. DOA is currently conducting water quality and risk assessment studies in and around the cave. The Service applauds DOA research efforts and encourages development of a management plan for their activities within the recharge area.

1.1.3 <u>Develop and implement Hering, Glover, and Brazelton cave Management Plan</u>. Part of a single drainage complex, these three caves and the surrounding (recharge) area are privately owned. The Service, or another appropriate State or Federal agency, should sponsor development of a cave management plan. The sponsoring agency should also facilitate community input and involvement, and provide information and assistance as outlined under Task 2.

2. <u>Develop technical information and educational material essential for cave and recharge area stewardship</u>. Local stewardship efforts can be encouraged by developing and providing technical information and related educational material to residents of cave recharge areas. Stewardship is needed to protect the groundwater habitat of the Alabama cave shrimp. Protection of groundwater is necessary to prevent extinction of the species.

2.1 <u>Delineate the groundwater basin (recharge area) for the Hering, Glover, and Brazelton cave complex and complete Bobcat Cave delineation studies</u>. The recharge area for Shelta Cave has been previously delineated but delineation is not yet completed for Bobcat Cave. The groundwater basins will be determined by potentiometric surface maps, fluorescent dye-tracing, aerial photography, and other applicable interpretive methods, and mapped. Major points for water entry (sinkholes, disappearing streams, etc.) to subterranean drainage systems, direction of flow, and resurgence points should be identified.

2.2 <u>Study and monitor hydrological patterns and groundwater withdrawal</u>. Determine recharge rates and volumes to aquifers for shrimp-inhabited caves by establishing and monitoring water level gauges within the caves. Correlate recharge rates and volumes with precipitation, and local stream discharge. Identify existing and accessible wells within the groundwater basins containing cave shrimp. Develop a monitoring program for these wells to determine utilization of the cave aquifers.

2.3 Periodically test water quality in caves inhabited by Alabama cave shrimp. Water quality samples should be taken from the caves and tested for pesticide, heavy metal, and petroleum hydrocarbon pollutants. If samples indicate problems, the sampling effort should be increased as appropriate to determine contaminant sources.

2.4 Develop and distribute educational materials on cave and groundwater habitats and communities. Outreach efforts should focus on people living within the recharge area of shrimp-inhabited caves. General information on the Alabama cave shrimp, cave habitats, cave communities, and groundwater protection can be distributed through printed materials, slide shows, videos, technical assistance workshops, or educational seminars by the Service, NSS, and other partners.

3. Monitor Alabama cave shrimp populations. The status of cave shrimp populations must be periodically monitored in order to determine the effect of recovery actions, and to document changes or trends as they occur. Monitoring methods should be standardized across all caves so that the information obtained will be comparable.

4. Conduct life history and other needed research. Few data are available on the ecology and life history of the Alabama cave shrimp. Population levels are currently too low to risk individuals in studies that may result in mortality. Studies such as species fecundity, mortality rate, turnover rate, longevity, food preference, habits, predation, etc., should be initiated when, and if, it is determined that they will have no impact on the ability of the species to survive.

5. Continue searching for additional Alabama cave shrimp populations. The location and protection of unknown cave shrimp populations that may exist in separate groundwater basins will be necessary to meet recovery objectives.

5.1 Periodically survey sites that offer potential habitat. Caves in which no shrimp are located, but which contain potential habitat (i.e., permanent or seasonal pools) should be periodically surveyed for the species for a period of 10 years. Survey efforts should focus around the karst areas of Madison and Jackson counties.

5.2 Develop and implement a management and protection plan for newly discovered populations. Caves which are found to contain previously unknown populations should be assessed for protection needs by the Service. Management and protection plans for each site should be developed and implemented.

6. Modify or replace gated entrance to Shelta Cave. Improper gating of the entrance to Shelta Cave has been implicated in the disappearance of the maternal colony of gray bats from the cave and an associated decrease in organic input to the ecosystem (Hobbs and Bagley 1989). The National Speleological Society should be encouraged to modify the entrance gating, using the most recently developed and proven techniques, to allow gray bat access.

7. Assess the suitability and feasibility for re-introduction of extirpated Alabama cave shrimp into Shelta Cave. Five separate groundwater basins containing a viable population of Alabama cave shrimp are required for reclassification. Shelta Cave, the type locality, historically contained high numbers of shrimp; no shrimp have been detected since 1973. If water quality and other habitat parameters improve, restoration of the shrimp to Shelta Cave may be possible.

8. Assess the overall success of the recovery program and recommend action (changes in recovery objectives, changes in classification, implement new measures, etc.). The recovery plan must be evaluated periodically to determine if it is on track and to recommend further actions.

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III. IMPLEMENTATION SCHEDULE

This Implementation Schedule outlines recovery actions and their estimated costs for the first 3 years of the recovery program. It is a guide for achieving objectives discussed in Part II of this plan. This Schedule indicates task priorities, task numbers, task descriptions, duration of tasks, responsible agencies, and estimated costs.

Priorities in column 1 of the following Implementation Schedule are assigned as follows:

1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

2 - An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.

3 - All other actions necessary to meet the recovery objective.

Key to acronyms used in Implementation Schedule

ADCNR	-	Alabama Department of Conservation and Natural Resources
ADEM	-	Alabama Department of Environmental Management
DOA	-	Redstone Arsenal, U.S. Department of the Army
GSA	-	Geological Survey of Alabama
NSS	-	National Speleological Society
BRD	-	Biological Resource Division, U.S.G.S.
NRCS	-	Natural Resources Conservation Service, U.S.D.A.
Pvt	-	Private land owner(s)
ES	-	Ecological Services,U.S. Fish and Wildlife Service

IMPLEMENTATION SCHEDULE

Priority	Task Number	Task Description	Task Duration	Responsible Agency FWS	Responsible Agency Other	Cost Estimates ($000s) FY1	FY2	FY3	Comments
1	1.1.2	Develop and implement Bobcat Cave Management Plan.	ongoing	ES	DOA	15.0			Implementation costs unknown.
1	1.1.3	Develop and implement Hering, Glover, and Brazelton cave Management Plan.	ongoing	ES	Pvt GSA	15.0			Need information from tasks 2.1 and 2.2; implementation costs unknown.
1	2.1	Delineate groundwater basin (recharge area) for Hering, Glover, Brazelton, and Bobcat caves.	3 yrs.	ES	DOA GSA	30.0	20.0	10.0	This task needs to be completed before task 1.1.3 can be completed.
2	2.2	Study and monitor hydrological patterns and groundwater withdrawal.	3 yrs.	ES	DOA GSA	10.0	10.0	10.0	
2	2.3	Test water quality in caves inhabited by Alabama cave shrimp.	ongoing	ES	ADCNR DOA GSA Pvt BRD NSS	5.0	5.0	5.0	
2	2.4	Develop and distribute educational materials on cave and groundwater habitats and communities.	ongoing	ES	ADCNR ADEM DOA GSA BRD NRCS NSS	5.0	10.0	5.0	

IMPLEMENTATION SCHEDULE

Priority	Task Number	Task Description	Task Duration	Responsible Agency FWS	Responsible Agency Other	Cost Estimates ($000s) FY1	FY2	FY3	Comments
2	3.0	Monitor Alabama cave shrimp populations.	ongoing	ES	ADCNR DOA GSA Pvt BRD NSS	---	---	---	Use existing program funding.
2	4.0	Conduct life history and other needed research.	ongoing	ES	ADCNR DOA GSA BRD NSS				Cost will depend on research needs.
3	1.1.1	Develop and implement Shelta Cave Management Plan.	ongoing	ES	NSS	5.0			Implementation costs unknown.
3	5.1	Periodically survey sites that offer potential habitat.	10 yrs.	ES	ADCNR GSA NSS	1.0	---	1.0	
3	5.2	Develop & implement management/ protection plan for newly discovered populations.	10 yrs.	ES	ADCNR GSA				Need information from task 5.1.
3	6.0	Modify or replace gated entrance to Shelta Cave.	2 yrs.	ES	NSS	20.0	---	---	
3	7.0	Assess reintroduction of shrimp to Shelta Cave.	ongoing	ES	ADCNR GSA DOA BRD NSS				Need information from task 1.1.1, 2.2, 2.3, 3.0, 6.0.
3	8.0	Assess the success of the recovery program.	ongoing	ES					Use existing program funds.

APPENDIX A

Excerpts of Geological Survey of Alabama reports

Selected excerpts of reports, made during cave visits to Bobcat, Brazelton, Glover, and Hering caves, copied, with permission, from the Geological Survey of Alabama cave investigations of Rheams *et al.* 1992 or McGregor *et al.* 1994.

BOBCAT CAVE

Date Oct. 8, 1992
Time In - 3:15 P.M. Out - 4:45 P.M.
Cave Number AL 1283 **County** Madison **Quadrangle** Madison

A. Cave Physical Description

1. Entrance break in rock on top of small hill; short, steep slope leads to main cave level.
2. Main Passageway Length = 1,490 feet mapped.
   Description low (ceiling heights average 4 feet), muddy rooms; main passage and trunk passages trend north-south.
3. Physical Notations
   a) General geology Geologic unit = Tuscumbia Limestone.
   Lithologic description light-gray bioclastic, micritic, or oolitic limestone with interbeds of nodular chert; cave passage appears developed along bedding planes and may be fracture controlled.
   Joints, fractures, etc. none observed.
   b) Hydrology cave wet with no stream; very slight seasonal flow.
   c) Description of water body small, isolated seasonal pools of water in the main room; water temperature = NA.; specific conductance = 220.
   d) Pollution none observed.

B. Biological Survey

1. Plant Life
   Molds = 0 Fungi = 0 Green plant material = at the entrance
   Wood = 0 Roots = hanging through the stalactites near the Cottrell's Cave connection.
2. Bats (including guano piles and ceiling stains) none
3. Other Mammals (tracks, bones, etc) pair of unidentified (raccoon?) eyes shining in back of Shrimp Room.
4. Amphibians
   Salamanders - Larvae = 0 Adults = 0
   Frogs = 0
5. Reptiles none
6. Fish
   Blind cave fish = 50+ (Typhlichthys subterraneus) collected = 0
   Other fish species = 0 collected = 0
7. Invertebrates
   Shrimp = 12 (one gravid female with approximately 15 eggs)
   Blind crayfish = 50+ Cambarus (Aviticambarus) jonesi collected = 0
   Other crayfish = 0 collected = 0
   Amphipods = 0
   Isopods = 3 Millipedes = 0
   Crickets = abundant Ceuthophilus sp. near cave entrance
   Snails = 0 Others = 0

C. Safety Hazards deep mud; low ceiling.

D. Public Use moderate use; some trash near the entrance and near the connection with Cottrell's Cave.

E. Narrative Description sloping entrance to a low-ceiling (4 feet high) passageway that leads to room with small pools of water; raccoon tracks and scat near pools; long (up to 4 feet) roots descend through stalactites at the end of the main passage near the connection to Cottrell's Cave.

F. Survey Party

Stuart W. McGregor (Geological Survey of Alabama)
Thomas E. Shepard (Geological Survey of Alabama)

Additional Data

Date Oct. 14, 1992
Time In - 10:30 A.M. Out - 11:45 A..M.

A. Cave Physical Description

3. Physical Notations
   c) Description of water body water temperature = 15°C; specific conductance = 240.

B. Biological Survey

7. Invertebrates
   Shrimp = 7 (no gravid females observed)
   measurements = 22 mm (total length including rostrum)
   22 mm
   24.5 mm
   29 mm

F. Survey Party

Stuart W. McGregor (Geological Survey of Alabama)

Additional Data

Date Oct. 21, 1992
Time In - 10:25 A.M. Out - 11:30 A.M.

A. Cave Physical Description

3. Physical Notations
   c) Description of water body water temperature = 15°C; specific conductance = 260.

B. Biological Survey

7. Invertebrates
   Shrimp = 13 (no gravid females observed)
   measurements = 22.7 mm (total length including rortrum)
   24.9 mm
   25.5 mm
   26.6 mm
   26.6 mm
   27.0 mm
   27.2 mm
   27.2 mm
   29.4 mm

F. Survey Party

Stuart McGregor	(Geological Survey of Alabama)
Arthur Patrick	(NASA)
Greg Bums	(NASA)

Additional Data

Date Oct. 26, 1992
Time In - 4:00 P.M. Out - 5:10 P.M.

A. Cave Physical Description

3. Physical Notations
   c) Description of water body isolated pools up to 18 inches deep; water temperature = NA.

B. Biological Survey

3. Other Mammals (tracks, bones, etc.) skull and jawbone with teeth (bobcat?)

6. Fish Blind cave fish = 50+ (Typhlichthys subterraneus; up to 3.5 inches long)
Other fish species = 0 collected = 0

7. Invertebrates
Shrimp = 9 (one gravid female; one very small juvenile)
Blind crayfish = 67 collected = 0
Other crayfish = 0 collected = 0
Amphipods = 0
Isopods = 2 Millipedes = 0
Crickets = abundant Ceuthophilus sp. near cave entrance
Snails = 0 Others = 0

F. Survey Party
Karen F. Rheams (Geological Survey of Alabama)
Dorothy E. Raymond (Geological Survey of Alabama)
Randall Blackwood (NSS)

Additional Data

Date Nov. 4, 1992
Time In - 2:40 P.M. Out - 4:30 P.M.

A. Cave Physical Description

3. Physical Notations
c) Description of water body water levels increased due to heavy rain; water temperature = NA.; specific conductance = 230.

B. Biological Survey

7. Invertebrates
Shrimp = 7 (no gravid females observed)
measurements = 20 mm (total length including rostrum)
26 mm
26.1 mm
27.2 mm

F. Survey Party
Stuart W. McGregor (Geological Survey of Alabama)

Additional Data

Date Nov. 10, 1992
Time In - 11:40 A.M. Out - 12:00 noon

A. Cave Physical Description

3. Physical Notations
c) Description of water body water temperature = NA.

B. Biological Survey

6. Fish
Blind cave fish = 3+ (Typhlichthys subterraneus) collected = 0

7. Invertebrates
Shrimp = 0
Blind crayfish = 3+ collected = 0

E. Narrative Description cave nearly sumped by high water; several cave fish and cave crayfish were observed at the entrance.

F. Survey Party
Stuart W. McGregor (Geological Survey of Alabama)

Additional Data

Date Nov. 17, 1992
Time In - 10:10 A.M. Out - 10:20 A.M.
A. Cave Physical Description
3. Physical Notations
c) Description of water body water temperature = NA.
B. Biological Survey
7. Invertebrates
Shrimp = 0
Crickets = abundant Ceuthophilus sp. near cave entrance; some mating observed.

E. Narrative Description cave sumped by high water; continuous water-quality monitors and recorders installed in the permanent window in Bobcat Cave and in the monitoring well near Bobcat Cave.

F. Survey Party

Stuart W. McGregor	(Geological Survey of Alabama)
Patrick E. O'Neil	(Geological Survey of Alabama)

Additional Data

Date: March 23, 1993
Time: In- 10:10 A.M. Out- 10:15 P.M.
B. Biological Survey:
7. Invertebrates:
Shrimp = 0
Blind crayfish = 10

E. Narrative Description: Entrance sumped; water temperature = 16.2°C; conductance 238; D.O. = 8.1 ppm; pH = 6.83. Water quality and quarterly counts made.

F. Survey Party:

Stuart W. McGregor	(Geological Survey of Alabama)
Patrick E. O'Neil	(Geological Survey of Alabama)
Thomas E. Shepard	(Geological Survey of Alabama)

Additional Data

Date April 13, 1993
Time In - 10:50 A.M. Out - 11:00 A.M.
A. Cave Physical Description
3. Physical Notations
c) Description of water body water temperature = NA.
B. Biological Survey
7. Invertebrates
Shrimp = 0
Blind crayfish = 1 collected = 0
Crickets = numerous Ceuthophilus sp. near cave entrance
Other = numerous flies (Diptera) and mosquitoes (Culicidae)

F. Survey Party

Stuart W. McGregor	(Geological Survey of Alabama)

Additional Data

Date June 8, 1993
Time In - 1:20 P.M. Out - 1:40 P.M.
A. Cave Physical Description

3. Physical Notations
   c) Description of water body water temperature = NA.

B. Biological Survey

4. Amphibians
   Salamanders - Larvae = 0   Adults = 1 Tennessee cave salamander (*Gyrinophilus palleucus*)

6. Fish
   Blind cave fish = 15 (*Typhlichthys subterraneus*) collected = 0

7. Invertebrates
   Shrimp = 0
   Blind crayfish = 7   collected = 0
   Others = abundant mosquitoes (Culicidae), gnats (Diptera), and crane flies (Tipulidae) at the entrance

E. Narrative Description quarterly water-quality samples collected.

F. Survey Party

Stuart W. McGregor   (Geological Survey of Alabama)

Additional Data

Date June 23, 1993
Time In - 10:45 A.M.   Out - 11:30 A.M.

A. Cave Physical Description

3. Physical Notations
   c) Description of water body water temperature = NA.

B. Biological Survey

6. Fish
   Blind cave fish = 10+ (*Typhlichthys subterraneus*) collected = 0
   Other fish species = 0   collected = 0

7. Invertebrates
   Shrimp = 8 (no gravid females)
   measurements: 24mm
   Blind crayfish = 10+   collected = 0
   Other = insects on water surface at entrance

E. Narrative Description weekly counts of aquatic fauna (with emphasis on cave shrimp) begin; water levels are decreasing to a workable stage.

F. Survey Party

Stuart W. McGregor   (Geological Survey of Alabama)
Randall Blackwood   (NSS)
Harold Blackwood   (NSS)

Additional Data

Date July 9, 1993
Time In - 2:17 P.M.   Out - 3:15 P.M

A. Cave Physical Description

c) Description of water body large pools in Shrimp Room; depth approximately 3-3.5 feet; water temperature = 58°F; specific conductance = 180.

B. Biological Survey

4. Amphibians
   Salamanders - Larvae = 1   Adults = 2 cave salamanders (*Eurycea lucifuga*)
   2 slimy salamanders (*Plethodon glutinosus*)

6. Fish
   Blind cave fish = 35 (*Typhlichthys subterraneus*)   collected = 0

Other fish species = 0 collected = 0

7. Invertebrates

Shrimp = 5 (one gravid female, size not available; one very small, young of year)
measurements = 20 mm (total length including rostrum)
20 mm
25 mm

Blind crayfish = 47 collected = 0
Other crayfish = 0 collected = 0

E. Narrative Description pools present in the Shrimp Room are still too extensive to permit an accurate investigation.

F. Survey Party

Karen F. Rheams	(Geological Survey of Alabama)
Frank H. Herring	(NSS)
Dave McDonald	(Visitor)

Additional Data

Date July 14, 1993
Time In - 9:25 A.M. Out - 10:25 A.M

A. Cave Physical Description

c) Description of water body water temperature = NA.

B. Biological Survey

4. Amphibians

Salamanders - Larvae = 0 Adults = 1 Tennessee cave salamander (*Gyrinophilus palleucus*)

6. Fish

Blind cave fish = observed (*Typhlichthys subterraneus*) collected = 0

7. Invertebrates

Shrimp = 11 (3 gravid females); measurements (total length including rostrum):
25 mm (gravid female)
27 mm (gravid female)
28 mm (gravid female)
23 mm (4 males?)
16 mm (subadult?)
19 mm (subadult?)
21 mm (subadult?)
NA

Blind crayfish = observed collected = 0

F. Survey Party

Stuart W. McGregor (Geological Survey of Alabama)

Additional Data

Date July 23, 1993
Time In - NA. Out - NA.

A. Cave Physical Description

c) Description of water body water temperature = NA

B. Biological Survey

7. Invertebrates

Shrimp = none observed in entrance water

E. Narrative Description cave sumped; inaccessible; Redstone Arsenal had recorded 5+ inches of rain during the previous week in the vicinity of Bobcat Cave.

F. Survey Party

Stuart W. McGregor (Geological Survey of Alabama)
Frank H. Herring (NSS)

Additional Data

Date August 5, 1993
Time In - 11:20 A.M. Out - 12:25 P.M.
A. Cave Physical Description
c) Description of water body water approximately 3 feet deep; water temperature = NA.
B. Biological Survey
6. Fish
Blind cave fish = observed (*Typhlichthys subterraneus*) collected = 0
7. Invertebrates
Shrimp = 0
Blind crayfish = observed collected = 0
F. Survey Party
Stuart W. McGregor (Geological Survey of Alabama)
Randall Blackwood (NSS)

Additional Data

Date August 10, 1993
Time In - 2:45 P.M. Out - 3:20 P.M.
A. Cave Physical Description
c) Description of water body water approximately 3 feet deep and slightly turbid; water temperature = NA
B. Biological Survey
6. Fish
Blind cave fish = observed (*Typhlichthys subterraneus*) collected = 0
7. Invertebrates
Shrimp = 0
F. Survey Party
Stuart W. McGregor (Geological Survey of Alabama)

Additional Data

Date August 20, 1993
Time In - 11:30 A.M. Out - 12:30 P.M.
A. Cave Physical Description
c) Description of water body water levels still high, approximately 3 feet deep; thin silt film on water; water temperature = NA
B. Biological Survey
4. Amphibians
Salamanders - Larvae = 1 Adults = 1 slimy salamander (*Plethodon glutinosus*)
6. Fish
Blind cave fish = abundant (*Typhlichthys subterraneus*) collected = 0
7. Invertebrates
Shrimp = 0
Blind crayfish = abundant collected = 0
F. Survey Party
Karen F. Rheams (Geological Survey of Alabama)

Additional Data

Date August 25, 1993
Time In - 1:45 P.M. Out - 3:00 P.M.
A. Cave Physical Description
3. Physical Notations
   c) Description of water body water temperature = NA.
B. Biological Survey
6. Fish
   Blind cave fish = 50+ (Typhlichthys subterraneus) collected = 0
7. Invertebrates
   Shrimp = 5 (no gravid females); 12.7 mm (3 individuals) 25.0 mm (2 individuals)
   Blind crayfish = 50+ collected = 0
   Isopods = 1 white Millipedes = 0
   Other = 1 spider (Araneae)
F. Survey Party
   Karen F. Rheams (Geological Survey of Alabama)

Additional Data

Date Sept. 12, 1993
Time In - 2:10 P.M. Out - 3:30 P.M.
A. Cave Physical Description
3. Physical Notations
   c) Description of water body water temperature = NA.
B. Biological Survey
7. Invertebrates
   Shrimp = 10 (no gravid females)
   measurements: <12.7 mm (8 individuals; approximate total length including rostrum); 25.0 mm (2 individuals; approximate total length including rostrum)
F. Survey Party
   Randall Blackwood (NSS)
   Bart Coulter (NSS)

Additional Data

Date Sept. 13, 1993
Time In - 1:20 P.M. Out - 5:00 P.M.
A. Cave Physical Description
3. Physical Notations
   c) Description of water body water temperature = NA.
B. Biological Survey
4. Amphibians
   Salamanders - Larvae = 0 Adults = 1 Tennessee cave salamander (Gyrinophilus palleucus)
6. Fish
   Blind cave fish = abundant (Typhlichthys subterraneus) collected = 0
7. Invertebrates
   Shrimp = 10 (no gravid females); no measurements taken.
   Blind crayfish = abundant collected = 0
E. Narrative Description began tape and compass of windows in cave.

F. Survey Party

Karen F. Rheams (Geological Survey of Alabama)
Stuart W. McGregor (Geological Survey of Alabama)

Additional Data

Date Sept. 23, 1993
Time In - 10:40 A.M. Out - 11:15 A.M.
A. Cave Physical Description
3. Physical Notations
   c) Description of water body water temperature = NA.
B. Biological Survey
7. Invertebrates
   Shrimp = 4 (no gravid females)
   measurements = 17 mm (total length including rostrum)
   20 mm
   24 mm
   NA

F. Survey Party

Stuart W. McGregor (Geological Survey of Alabama)

Additional Data

Date Sept. 30, 1993
Time In - 11:30 A.M. Out - 2:00 P.M.
A. Cave Physical Description
3. Physical Notations
   c) Description of water body water temperature = NA.
B. Biological Survey
7. Invertebrates
   Shrimp = 11 (no gravid females)
   measurements = <3 mm (1 individual; approx. total length including rostrum); <12.7 mm (9 individuals); 19 mm (1 individual)

F. Survey Party

Karen F. Rheams (Geological Survey of Alabama)

Additional Data

Date Oct. 13, 1993
Time In - NA. Out - NA.
A. Cave Physical Description
3. Physical Notations
   c) Description of water body water temperature = NA.
B. Biological Survey
7. Invertebrates
   Shrimp = 2 (no gravid females)
   measurements = less than 12.7 mm (approximate length)

F. Survey Party

Karen F. Rheams (Geological Survey of Alabama)
Stuart W. McGregor (Geological Survey of Alabama)

Additional Data

Date Oct. 22, 1993
Time In - 10:50 A.M. Out - 11:10 A.M.
A. Cave Physical Description
3. Physical Notations
c) Description of water body water level is very low; water is only visible in the largest windows; water temperature = NA.
B. Biological Survey
7. Invertebrates
Shrimp = 1 (unknown sex); not measured
F. Survey Party
Stuart W. McGregor (Geological Survey of Alabama)

Additional Data

Date Oct. 28, 1993
Time In - 2:42 P.M. Out - 3:05 P.M.
A. Cave Physical Description
3. Physical Notations
c) Description of water body counterclockwise flow observed in monitored window; clockwise flow observed in large (10-foot long) window on west side of Shrimp Room; water temperature = NA.
B. Biological Survey
7. Invertebrates
Shrimp = 3 (unknown sex)
measurements = 25 mm (one individual)
F. Survey Party
Stuart W. McGregor (Geological Survey of Alabama)

Additional Data

Date Nov. 2, 1993
Time In - 11:00 A.M. Out - 11:15 A.M.
A. Cave Physical Description
3. Physical Notations
c) Description of water body water temperature = NA.
B. Biological Survey
7. Invertebrates
Shrimp = 2 (no gravid females)
measurements 20 mm
22 mm
F. Survey Party
Stuart W. McGregor (Geological Survey of Alabama)

Additional Data

Date Nov. 11, 1993
Time In - 1:00 P.M. Out - 1:20 P.M.
A. Cave Physical Description
3. Physical Notations
c) Description of water body water level approximately 1 foot below the probes in the monitored window; water temperature = NA.
B. Biological Survey

3. Other Mammals (tracks, bones, etc) very abundant raccoon activity (tracks, claw marks) at each window that contains water.

7. Invertebrates

Shrimp = 1 (unknown sex); not measured.

F. Survey Party

Karen F. Rheams (Geological Survey of Alabama)

Additional Data

Date Nov. 22, 1993

Time In - 8:30 A.M. Out - 8:45 A.M.

A. Cave Physical Description

3. Physical Notations

c) Description of water body water levels are increasing; isolated pools are nearly filled; monitor probes are in water; water in the monitored window is approximately 2 feet deep; water temperature = NA.

B. Biological Survey

7. Invertebrates

Shrimp = 0

F. Survey Party

Karen F. Rheams (Geological Survey of Alabama)

Additional Data

Date Nov. 24, 1993

Time In - 12:00 noon Out - 12:55 P.M.

A. Cave Physical Description

3. Physical Notations

c) Description of water body water temperature = NA.

B. Biological Survey

4. Amphibians

Salamanders - Larvae = 0 Adults = 1 Tennessee cave salamander (*Gyrinophilus palleucus*)

6. Fish

Blind cave fish = 22 (*Typhlichthys subterraneus*) collected = 0

7. Invertebrates

Shrimp = 1 (unknown sex); measurement = 15 mm

Blind crayfish = 27 collected = 0

Crickets = abundant *Ceuthophilus* sp. near cave entrance

F. Survey Party

Karen F. Rheams (Geological Survey of Alabama)

Randall Blackwood (NSS)

Additional Data

Date Nov. 30, 1993

Time In - 11:15 A.M. Out - 11:50 A.M.

A. Cave Physical Description

3. Physical Notations

c) Description of water body water temperature = NA.

B. Biological Survey

7. Invertebrates

Shrimp = 2 (no gravid females)

measurements 23 mm total length including rostrum

F. Survey Party

Stuart W. McGregor (Geological Survey of Alabama)

Additional Data

Date Dec. 10, 1993
Time In - 1:00 P.M. Out - 2:20 P.M.

A. Cave Physical Description

3. Physical Notations
   c) Description of water body water temperature = NA.

B. Biological Survey

4. Amphibians:
   Salamanders = 1 Tennessee cave salamander (Gyrinophilus palleucus)

7. Invertebrates
   Shrimp = 2 (no gravid females)
   measurements: 1= 18 mm total length including rostrum, 1= NA
   Blind crayfish = Cambarus (Aviticamburus) jonesi (collected)
   Crickets = Ceuthophilus sp. (collected)
   Millipedes = Diplopoda (collected)
   Spiders = Araneae (collected)
   Snails = Gastropoda, terrestrial, (collected)
   Flies = Diptera (unknown group) collected

F. Survey Party

Stuart W. McGregor	(Geological Survey of Alabama)
Horton H. Hobbs, III	(Wittenberg University)
Toby Dogwiler	(Wittenberg University)
Annette Summers	(Wittenberg University)
Larry Bond	(NSS)
Bill Stitzel	(NSS)

Additional Data

Date Dec. 15, 1993
Time In - 10:35 A.M. Out - 11:48 A.M.

A. Cave Physical Description

3. Physical Notations
   c) Description of water body isolated pools 1-3 feet deep; water temperature = 12.9°C; dissolved oxygen = 9.7; pH = 8.06; specific conductance = 262.

B. Biological Survey

6. Fish
   Blind cave fish = very abundant Typhlichthys subterraneus, up to 3 inches long
   collected = 0

7. Invertebrates
   Shrimp = 2 (no gravid females)
   Blind crayfish = numerous

F. Survey Party

Karen F. Rheams	(Geological Survey of Alabama)
Stuart W. McGregor	(Geological Survey of Alabama)

Additional Data

Date Feb. 14, 1994
Time In - 12:25 P.M. Out - 12:35 P.M.

A. Cave Physical Description

3. Physical Notations
   c) Description of water body cave sumped; water temperature = 14.4°C; dissolved oxygen = 9.3; pH = 7.34; specific conductance = 275.

B. **Biological Survey**
2. Bats (including ceiling stains and guano piles): 1 *Pipistrellus subflavus*
4. Amphibians: 1 smashed slimy salamander (*Plethodon glutinosus*)
7. Invertebrates
   Shrimp = 0
   Blind crayfish = 3

F. **Survey Party**

Stuart W. McGregor	(Geological Survey of Alabama)
Randall Blackwood	(NSS)

Additional Data

Date July 21, 1994
Time In - 12:20 P.M. Out - 1:10 P.M.

A. **Cave Physical Description**
3. Physical Notations
   c) Description of water body cave still flooded; water levels are unseasonably high as the result of heavy and more frequent than normal precipitation during the first part of the summer; water temperature = NA.

B. **Biological Survey**
4. Amphibians
   Salamanders - Larvae = 0 Adults = 1 slimy salamander (~~*Plethodon glutinosus*~~)
6. Fish
   Blind cave fish = 10 (*Typhlichthys subterraneus*) collected = 0
   Blind crayfish = 7
7. Invertebrates
   Shrimp = 0
   Millipedes = 2+, white
   Other = springtails (Collembola); very small, unidentified brownish "bugs" crawling on the bottom of a pool.

F. **Survey Party**

Karen F. Rheams	(Geological Survey of Alabama)
Jim Godwin	(Alabama Natural Heritage Program)

BRAZELTON CAVE

Date July 12, 1993
Time In - 10:28 A.M. Out - 11:27 A.M.
Cave Number AL 337 **County** Madison **Quadrangle** Moontown

A. Cave Physical Description

1. Entrance rocky streambed entrance at the base of a small limestone face; sand and mud banks along the stream bed.
2. Main Passageway Length = 1,929 feet mapped.
   Description predominantly an E/W-trending walking to stooping solution passage with numerous deep pools and seasonal stream flow.
3. Physical Notations
   a) General geology Geologic unit = Monteagle Limestone.
   Lithologic description light-gray oolitic limestone with interbeds of micritic, bioclastic limestone, dolomite, and dolomitic limestone.
   Joints, fractures, etc. none observed.
   b) Hydrology numerous permanent deep pools and cave lakes; strong, swift flow during times of increased precipitation.
   c) Description of water body 2 to 6 feet deep; water temperature = 59°F; specific conductance = 290
   d) Pollution none observed.

B. Biological Survey

1. Plant Life
   Molds = 0 Fungi = 0 Green plant material = 0
   Wood = 0 Roots = 0
2. Bats (including guano piles and ceiling stains) none
3. Other Mammals (tracks, bones, etc) evidence of beaver habitation (musky smell, woody debris) in one small side passage.
4. Amphibians
   Salamanders - Larvae = 0 Adults = 0
   Frogs = 0
5. Reptiles none
6. Fish
   Blind cave fish = 0 collected = 0
   Other fish species = 3 bream (Lepomis sp.) collected = 0
   5 banded sculpins (Cottus carolinae)
   1 minnow (Cyprinidae)
   1 large catfish (Ictaluridae)
7. Invertebrates
   Shrimp = 0
   Blind crayfish = 10 (Orconectes O. a. australis) collected = 0
   Other crayfish = 3 collected = 0
   Amphipods = 0
   Isopods = 0 Millipedes = 0
   Crickets = 0 Snails = 0 Others = 0

C. Safety Hazards deep water; flash flood potential ; very deep, cold water encountered; flotation vests and wetsuits required.

D. Public Use little use

E. Narrative Description revisit in an attempt to reach the shrimp pool at the east end of the cave to verify the reported population of Palaemonias alabamae; water was too deep to negotiate safely; trip was aborted when one member of the survey party exhibited symptoms of hypothermia; will attempt to revisit the cave during drier conditions in the Fall.

F. **Survey Party**

Karen F. Rheams	(Geological Survey of Alabama)
Stuart W. McGregor	(Geological Survey of Alabama)
Randall Blackwood	(NSS)
Frank Herring	(NSS)

Additional Data

Date: November 3, 1994
Time: In- 12:10 P.M. Out- 1:25 P.M.
B. Biological Survey:
3. Other Mammals (tracks, bones, etc) beaver (*Castor canadensis*) busy in entrance.
6. Fish
Other fish speices = numerous bream (*Lepomis*) collected = 0
numerous banded sculpins (*Cottus carolinae*) collected = 0

7. Invertebrates
Shrimp = 8 Lengths: 9 mm (plus one other about 9 mm)
16 mm
18 mm
24 mm
+ 3 not measured
Blind crayfish = several seen collected = 0
Other crayfish = several seen collected = 0
E. Narrative Description: NA
F. Survey Party:

Stuart W. McGregor	(Geological Survey of Alabama)
Randall Blackwood	(NSS)

GLOVER CAVE

Date: Nov. 14, 1990
Time: In - 2:30 P.M. Out - 5:00 P.M.
Cave Number: AL 54 **County:** Madison **Quadrangle:** New Hope

A. Cave Physical Description

1. Entrance: five cave entrances into Glover Cave are known; entrance 1 is a very tight crawl at the extreme eastern end of the cave (on the east side of the paved road); entrance 2 is a walk-in entrance in a sinkhole approximately 150 feet west of entrance 1 (on the west side of the paved road); entrance 3 is a pit (approximately 25 feet deep) less than 100 feet west of entrance 2; entrances 4 is in a sinkhole that is completely blocked by trash and debris at the western end of the cave; entrance 5 is located in a sinkhole approximately 800 feet west of entrance 4 but deep water prevented access to an upper ledge that leads into the main passage; for this trip, Glover Cave was accessed using entrances 1 and 2.
2. Main Passageway: 7,000 feet mapped; generally trends east-west.
   Description: fairly straight tunnel-like stream passage that ranges from upright walking passage to low crawls; very few side passages off the main tunnel; cave bottom is predominantly sandy with some gravel areas; deep stagnant water (4-5 feet deep, 100-150 feet long) was encountered just west the pit entrance; deep water also occurs at Little Lake Geneva and just inside entrance 5.
3. Physical Notations:
   a) General geology: Geologic unit = Monteagle Limestone.
   Lithologic description: light-gray oolitic limestone with interbeds of micritic, bioclastic limestone, dolomite, and dolomitic limestone and limestone with nodular chert; light-gray chert nodules range from pebble to boulder sized; abundant horn corals weathering out of the walls and ceiling; some well-preserved colony corals are also present.
   Joints, fractures, etc.: conjugate joint sets (northeast/southwest and northwest/southeast) are visible on the ceiling throughout most of the main passage; the main cave passage (east-west) bisects this conjugate joint set pattern.
   b) Hydrology: seasonal flow; cave lakes; there is evidence for fast, deep water flow through the cave during wet seasons.
   c) Description of water body: lake near entrance 3 is approximately 4-5 feet deep and 100-150 feet long by 10 feet wide; Little Lake Geneva near entrance 4 is approximately 5-6 feet deep, +300 long by 10 feet wide; lake just inside entrance 5 is 5-6 feet deep, 15-20 feet long by 20-25 feet wide; water temperature = 11.5°C.
   d) Pollution: abundant trash and debris have washed into the cave during periods of strong water flow; car batteries, oil cans, 50-gallon drums, PVC pipe, household garbage, etc. were observed as far back as Little Lake Geneva; entrance 4 is completely blocked by trash, debris, and household garbage.

B. Biological Survey:

1. Plant Life:
   Molds = 0 Fungi = 0 Green plant material = 0 Wood = 0
   Roots = abundant roots hanging from the ceiling and growing on the mud banks in the cave section called "Hanging Gardens"; hanging roots are as much as 4 feet long.
2. Bats (including guano piles and ceiling stains): 4 (hibernating Pipistrelles?)
3. Other Mammals (tracks, bones, etc): none
4. Amphibians:
   Salamanders - Larvae = 0 Adults = 1 (black)
   Frogs = 0
5. Reptiles: none
6. Fish:

Blind cave fish = 4 *T. subterraneus*		collected = 0
Other fish species =	5 banded sculpin (*Cottus carolinae*)	collected = 0
	1 sunfish (*Lepomis* sp.)	collected = 0
	1 minnow (*Notropis* sp.)	collected = 0

7. Invertebrates:

Shrimp = 0
Blind crayfish = 15 collected = 0
Other crayfish = 0 collected = 0
Amphipods = 0
Isopods = 0 Millipedes = 0
Crickets = very abundant Snails = 0

C. Safety Hazards: deep, cold water; low ceiling in places; flash flood potential.

D. Public Use: moderate use; abundant trash and debris throughout main cave passage.

E. Narrative Description: rounded, tunnel-shaped, slightly meandering seasonal stream passage; flow exiting the entrance of Hering Cave enters Glover Cave at entrance 1; large quantities of sand occur along the cave floor; substantial evidence for high-energy water flow during the wet season (vegetation debris stuck into ceiling, abundant large and small trash items); cave contains three (apparently year-round) standing pools of deep, cold water; aquatic collection net was lost while traversing deep water near entrance 3, which prohibited collection of aquatic species. Cave trip was extremely strenuous as a result of the distance to Little Lake Geneva and the effects of the cold water near entrance 3; trip was terminated at the east bank of Little Lake Geneva.

F. Survey Party:

Karen F. Rheams	(Geological Survey of Alabama)
Paul H. Moser	(Geological Survey of Alabama)
Stuart W. McGregor	(Geological Survey of Alabama)
Jerry Rogers	(Geological Survey of Alabama)
Paul Hartfield	(U.S. Fish and Wildlife Service)

ADDITIONAL DATA:

Date: Oct. 29, 1991
Time: In - 1:00 P.M. Out - 3:00 P.M.

B. Biological Survey:

4. Amphibians:

Frogs = 2

6. Fish:

Blind cave fish = 50+ *T. subterraneous*		collected = 0
Other fish species =	stone rollers (*Campostoma oligolepis*)	collected = 0
	sculpins (*Cottus carolinae*)	collected = 0
	bullhead catfish (*Ictalurus* sp)	collected = 0
	sunfish (*Lepomis* sp)	collected = 0

7. Invertebrates:

Shrimp = 4 (in shallow isolated pool just east of Little Lake Geneva)
Blind crayfish= 49+ collected = 0

F. Survey Party:

Karen F. Rheams	(Geological Survey of Alabama)
Stuart W. McGregor	(Geological Survey of Alabama)
Randall Blackwood	(National Speleological Society)

Date: Nov. 6, 1991
Time: In - 4:00 P.M. Out - 4:25 P.M.

B. Biological Survey:

6. Fish:

Blind cave fish = 1 T. subterraneous		collected = 0
Other fish species =	1 banded sculpin (*Cottus carolinae*)	collected = 0
	3 creek chub (*Semotilus atromaculatus*)	collected = 0
	2 spotted suckers (*Catostomus commersoni*)	collected = 0
	2 black bullheads (*Ictalurus melas*)	collected = 0
	1 green sunfish (*Lepomis cyanellus*)	collected = 0

F. Survey Party:

Stuart W. McGregor	(Geological Survey of Alabama)
Thomas E. Shepard	(Geological Survey of Alabama)

Date: July 23, 1992
Time: In - NA Out - NA
E. Narrative Description: swift flowing stream from Hering Cave completely covers bottom of sinkhole at Glover Cave entrance 2; debris in large entrance sinkhole has been recently removed by volunteers from the Huntsville Grotto of the National Speleological Society; entrance to cave was not attempted at this time.
F. Survey Party:

Karen F. Rheams	(Geological Survey of Alabama)
Paul H. Moser	(Geological Survey of Alabama)
Stuart W. McGregor	(Geological Survey of Alabama)
Randall Blackwood	(National Speleological Society)
Danny Dunn	(Redstone Arsenal)
Paul Hartfield	(U.S. Fish and Wildlife Service)

HERING CAVE

Date July 9, 1993
Time In - 12:30 P.M. Out - 1:30 P.M.
Cave Number AL County Madison **Quadrangle** New Hope

A. Cave Physical Description

1. Entrance large (15 feet high by 25 feet wide) tunnel-like stream entrance; large boulder-strewn outflow channel from the cave entrance; deep water (3-4 feet) encountered immediately inside entrance.
2. Main Passageway Length = 6,100 feet mapped.
   Description walking stream passage to the north/northeast; predominantly high ceiling (+10 feet).
3. Physical Notations
   a) General geology Geologic unit = Monteagle Limestone.
   Lithologic description thin-bedded white to light-gray limestone with interbeds of white to light-gray nodular chert; abundant horn coral fossils are visible in the walls and ceiling; some fossilized colony corals observed; some helectites.
   Joints, fractures, etc. conjugate joint set at approximately 45° to the trend of the main passage (N-S); cave passage predominantly bisects this conjugate joint set.
   b) Hydrology constant stream flow to the south/southwest.
   c) Description of water body depth is 3.5-4 feet just past entrance; stream flowing back in cave, but disappears into sand before reaching entrance; water temperature = NA.
   d) Pollution graffiti in first big room.

B. Biological Survey

1. Plant Life
   Molds = 0 Fungi = 0 Green plant material = 0
   Wood = 0 Roots = 0
2. Bats (including guano piles and ceiling stains) 1 (in flight)
3. Other Mammals (tracks, bones, etc) none
4. Amphibians
   Salamanders - Larvae = 0 Adults = 0
5. Reptiles none
6. Fish
   Blind cave fish = 0 collected = 0
   Other fish species = 0 collected = 0
7. Invertebrates
   Shrimp = 0
   Blind crayfish = 12 collected = 0
   Other crayfish = 0 collected = 0
   Amphipods = 0
   Isopods = 0 Millipedes = 0
   Snails = 0 Others = 0

C. Safety Hazards deep water; flash flood potential.

D. Public Use moderate use.

E. Narrative Description high-ceiling (10-25 feet high), walking stream passage with some areas of deep water; cave floods completely during rainy periods; water exits the entrance of Hering Cave and flows 200-250 feet W/NW into the entrance of Glover Cave.

F. Survey Party

Karen F. Rheams (Geological Survey of Alabama)
Frank Herring (NSS)
Dave McDonald (Visitor)

Additional Data

Date September 16, 1993
Time In - 10:00 A.M. Out - 10:30 A.M.
B. Biological Survey
2. Bats (including guano piles and ceiling stains) 1 flying.
6. Fish
   Blind cave fish= 8 collected= 0
7. Invertebrates
   Shrimp=3 (in single pool)
   Blind crayfish=12 collected=0

F. Survey Party

Stuart W. McGregor	(Geological Survey of Alabama)
Patrick E. O'Neil	(Geological Survey of Alabama)

Date October 13, 1993
Time In - 4:30 P.M. Out - 5:30 P.M.
B. Biological Survey
6. Fish
   Blind cave fish = 1 (*Typhlichthys subterraneus*) collected=0
   Other fish species = 2 banded sculpins (*Cottus carolinae*) collected=0
7. Invertebrates
   Blind crayfish = observed collected=0

F. Survey Party

Karen F. Rheams	(Geological Survey of Alabama)
Stuart W. McGregor	(Geological Survey of Alabama)
Carl Couret	(U.S. Fish and Wildlife Service)
Greg Burns	(NASA)
Danny Dunn	(RSA)

Date November 22, 1993
Time In-NA A.M. Out-NA P.M.
E. Narrative Description water flowing out of entrance and disappearing into hole on south side of stream channel approximately half way to Glover Cave entrance; water pooled in entrance; inaccessible without wading; entry not attempted.

F. Survey Party

Karen F. Rheams	(Geological Survey of Alabama)

APPENDIX B

List of Reviewers

Mr. Charles Kelly
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and Natural Resources
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Commander
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*Independent Peer Reviewers

APPENDIX C

Comments Received on Draft Recovery Plan

NORTH CAROLINA
State Museum of Natural Sciences
FOUNDED 1879

19 October 1996

Dr. Robert Bowker
Jackson Field Office
U.S. Fish and Wildlife Service
6578 Dogwood View Parkway
Suite A
Jackson, MS 39213

NOV - 4 1996

Dear Dr. Bowker:

I received the draft recovery plan for the Alabama cave shrimp on 11 October 1996. It is an admirable job and, when implemented, should certainly go far in protecting the shrimp, its habitats, and its associates.

Enclosed are my specific comments. If you have any questions about them, please do not hesitate to contact me.

Thank you for the opportunity to contribute to this important project.

Sincerely yours,

John E. Cooper

Encl.: 4 pp.

John E. Cooper, Ph.D.

Betsy Bennett, Director
Bicentennial Plaza P.O. Box 29555 Raleigh, North Carolina 27626 FAX (919) 733-1573 (919) 733-7450
A Division of the North Carolina Department of Environment, Health, and Natural Resources

Observations and Suggestions

1. P.1, line 10: Could replace Rheams et al. (1992), which is an open-file report, with Rheams et al. (1994), a published source.

2. P.4, line 10: Replace "another" with "a" (there are no other Jackson County caves in which the shrimp ostensibly has been sighted).

3. P.4: On the apparent extirpation of P. alabamae from Shelta Cave, I still have a wee modicum of skepticism about the amount of time spent searching for the beast. Martha Cooper and I spent many hundreds of hours in the cave, often 8 to 10 or more hours in a single trip, making our observations. On the other hand, the people involved in the recent surveys were certainly good field personnel. In addition, pollution of the aquifer, and the apparent reduction in numbers of the other species comprising the aquatic fauna, would make a strong argument that the shrimp is indeed gone from Shelta. Some effort should be made to find it, and other Shelta aquatics, at the resurgence of the cave's waters (Brahan Spring).

4. P.4: On seasonal occurrence, Cooper (1975:130-131) indicated that the decreases in numbers of shrimp observed during high water levels might be a consequence of habitat expansion "with consequent decreased density," which "may render these small animals even more inconspicuous than usual." This doesn't mean that they don't "occur" at such times, just that they may be much more dispersed and more difficult to find. Conversely, as water levels drop, habitat becomes compressed and observed numbers ("density") increases.

5. P.5, para. 2, line 2: Between "reported by" and "Cooper (1975)," add "Cooper and Cooper (1974)." Then add the following reference to the Literature Cited: Cooper, J.E. and M.R. Cooper. 1974. Distribution and ecology of troglobitic shrimp of the genus Palaemonias (Decapoda: Atyidae). Association of Southeastern Biologists Bulletin 21(2):48.

6. P.7, para. 1: Although of no great import, the occurrence of windows that provide aquatic troglobites with access to deeper groundwater levels was extensively reported in Shelta Cave (Cooper 1975:28, 185-189, etc.). One of the animals found at these windows was P. alabamae (Cooper 1975:130, 133).

7. P.8, para. 1: Rheams et al. (1994:30) indicated that the lowest levels of Shelta Cave may be developed in the Fort Payne Chert.

8. P.8, last para.: Water levels in Shelta Cave during my study fluctuated by as much as 6.7 m (Cooper 1975:105, 106, 110).

9. P.11, para. 1, lines 3-5: Lisowski reported this same behavior in P. ganteri in Mammoth Cave.

10. P.11, para. 2: Again of no great import, but Cooper (1975: 46, 63, 110) discussed the significant contributions of the existing gray bat maternity colony to the aquatic community of Shelta Cave.

11. P.12: On the number of eggs carried by P. alabamae, Cooper (1975:138) reported the observed number of attached ova to be 4 on one female and 9 on the other, not 4 to 30 (the 30 was for P. ganteri). In P. alabamae, the actual number is almost certainly 8 to 12. Rheams et al. (1992:68, 70) reported shrimp in Bobcat Cave carrying 20 to 24 ova, which is probably a size-related phenomenon; the Bobcat shrimp are larger than the Shelta shrimp.

12. P.12, para. 1, last line: On "at least one growing season to reach sexual maturity," here are comments I made in a letter to Stuart McGregor (7 April 1995) in a review of a GSA open-file manuscript: "This implies that P. alabamae may attain sexual maturity in 'one growing season,' and the fact that both mature and 'smaller' individuals exist in the same population does not necessarily support this; we really know nothing of the growth (age, maturation) rate of this shrimp and, if it follows the growth and maturation trends we observed in the Shelta crayfishes, the 'smaller' individuals could be at least several years old." I suppose that the qualifier -- "at least" -- implies that attainment of sexual maturity could involve a number of years. And see comment 23.

13. P.12: On sexual dimorphism in P. alabamae, Cooper (1975:137) reported that females averaged 1.8 mm larger than males in total length and 0.8 mm in carapace length. The main size difference between the sexes was in length of abdomen, with females averaging 1.2 mm longer (abdomen) than males.

14. P.12: On longevity in P. ganteri, the only "evidence" I can find for Leitheuser's (1988:17) estimate of 10 to 15 years is in a progress report by Holsinger and Leitheuser (1983: 2-3), wherein data from growth rates of specimens kept in aquaria were used to estimate longevity. This is a reasonable tactic, but in a different 1983 progress report (pp. 5-7) these investigators pointed out that their data were "very tentative," and perhaps even biased by the limitations of their procedures. Thus, the longevity estimates for this species, although not unreasonable, would appear to be moderately questionable. This longevity estimate is further confused by our lack of knowledge of the earliest stages in the life histories of the troglobitic atyids.

15. P.13, para. 1, last sentence: You might want to refer to primary references, such as Bosnak and Morgan (1981), and Dickson et al. (1979); references in Hobbs (1992).

16. P.13, para. 2: Our last work trip to Shelta Cave was during the period 12-17 July 1975. The results were not available to anyone currently working in Shelta until I sent them to

both Horton Hobbs III and Stuart McGregor in the spring of 1995. In summary, Martha and I spent 34 hours (68 person-hours) working intensively, and found that the populations of all three crayfish species were in excellent shape, and the *Typhlichthys* population was in at least good shape. The water levels were fairly high (wading in waist-deep water required to get into the western parts of the cave) and we observed no shrimp, which is not unusual during high water. Previously, the latest available reports of our work were for 1973.

17. P.15, para. 2, lines 1-3: The primary published reference for predation on the shrimp by *Typhlichthys* is Cooper and Cooper (1974:48). See comment 5. It was earlier mentioned in a paper submitted to the Fifth International Congress of Speleology (Stuttgart, 1969), the proceedings of which were not published until 1974.

18. P.15, para. 2, line 5: Change "several" to "two," and "crayfish" to "crayfishes" (the undescribed Shelta *Orconectes*, whose description was completed over a year ago and has been sent to a journal, is not a potential predator).

19. p.15, para. 2, lines 6-8: *Gyrinophilus palleucus* has also been reported a number of times from Bobcat Cave (see the Geological Survey of Alabama field reports), but no voucher specimens are known to me.

20. Pp.17-23, "Recovery," no comments.

21. P.24: Although I would not in any way dispute any comments Merlin Tuttle might have made on the possible return of a gray bat maternity colony to Shelta, the area has experienced considerable development and is well illuminated at night. This could certainly deter the return of bats, but again I defer completely to any of Merlin's opinions.

22. Pp.27-30, "Implementation Schedule," no comments.

23. P.36, line 3: For "Shrimp" the report lists "one very small young of year." Here are comments I made in the previously mentioned letter to Stuart McGregor (see item 12): "I seriously doubt that anyone could determine 'young-of-year,' since we know nothing about the life history, including potential number and duration of larval stages...." And later, "we have no idea if there are larval stages involved, how many, or their duration." I feel that zoea and larvae almost certainly occur. The only freshwater shrimp I know of in which larval stages are completely suppressed is the epigean palaemonid, *Palaemonetes mesogenitor*.

Nitpicking

(Sadly, once an editor, always an editor!)

1. P.1, lines 11, 13; p.4, line 7; p.7, last line; p.8, lines 1, 5; and MANY other places in the text: change Caves to caves (the word "caves" here is no longer a proper noun).
2. P.7, line 3: change reports to reported; line 4: comma after "variable;" line 5: change Coopers' to Cooper's.
3. P.10, line 1: comma after "areas."
4. P.11, para. 2, line 2: change grisecens to grisescens.
5. P.12, para 3, line 7: change Leithauser to Leitheuser.
6. P.14, line 2: LeGrand is spelled without the final "e" here, but is shown as LeGrande in the Literature Cited; which is correct?
7. P.15, para. 2, line 4: it's Tennessee cave salamander; line 8: change crayfish to crayfishes.
8. P.16, line 13: change Counties to counties.
9. PP.31-50: a number of spelling errors in these reports, but I'll not bother you with them. I previously pointed most of them out to Stuart McGregor, and I'm sure they'll be changed by him.

NOTE: I am preparing a manuscript, tentatively titled "Observations on the biology of the troglobitic shrimps, *Palaemonias alabamae* and *Palaemonias ganteri* (Decapoda: Atyidae)," co-authored with Martha R. Cooper. I will not be able to complete this paper until the current GSA open-file report by McGregor et al. is converted to a publication, which would appear to be imminent. I'll keep your office informed of progress.

GEOLOGICAL SURVEY OF ALABAMA

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JAMES D. MOORE
Acting State Geologist

November 1, 1996

Ms. Theresa Jacobson
USFWS
6578 Dogwood View Pkwy.
Jackson, MS 39213

Dear Terry,

Only a few comments regarding the Alabama Cave Shrimp Recovery Plan.

1. In the Executive Summary and in the section on Recovery Objectives, p. 17, ¶ 2, and possibly elsewhere, you refer to 5 ground water basins where the shrimp are known to occur or to have occurred in the past. Shelta and Bobcat Caves basins are certainly distinct from one another and from Hering/Glover/Brazelton system. However, H/G/B system is clearly one system, for a total of three known basins. Is there a FWS or other policy that dictates that individual caves be referred to as discrete basins, giving a total of five basins?

2. In section on Habitat, p. 8, ¶ 2, you state that Shelta and Bobcat Caves are located within the city limits of Huntsville. I'm not certain that Bobcat in actually within the political boundary of Huntsville, though it certainly could be affected by the urban sprawl of Huntsville.

3. Also in section on Habitat, p. 11, ¶ 2, last line, you mention that individual bats have been seen in Glover and Hering Caves. A single Pipistrellus subflavus was seen on numerous visits to Bobcat Cave. See Field Sheet in Appendix A for February 14, 1993, p. 42-43. I distinctly remember seeing the bat in the entrance for several weeks in a row.

4. In section on Recovery, 2.1, p. 20, you state that recharge areas for Shelta and Bobcat Caves have been previously delineated. Actually, we have made strides in Bobcat Cave's delineation, however, I would not feel comfortable calling it complete. We are in the process of initiating a new tracer-dye study to further define the recharge of Bobcat even as I type.

5. In list of reviewers, p. 52, I am identified as "Stewart" McGregor. I am actually Stuart McGregor. A minor oversight, but technically incorrect!

Overall, I think the recovery plan is plausible based on current knowledge of the animal and its environs. Logical steps toward reasonable objectives are presented, inclusive of possible roadblocks that may be encountered. Please let us know if we can be of further assistance.

T. - Hope this helps -

Stuart

Stuart W. McGregor

FYI -
we have e-mail! Stuart@OGB.GSA.TUSCALOOSA.AL.US

DEPARTMENT OF ZOOLOGY
THE UNIVERSITY OF TEXAS AT AUSTIN
Austin, Texas 78712-1064 · FAX (512) 471-9651

NOV 18 1996

Memo
To: Robert Bowker, Field Supervisor
USDI Fish and Wildlife Service, Jackson Field Office
From: Society for Conservation Biology
Re: Technical/Agency Draft Recovery Plan for the Alabama Cave Shrimp (*Palaemonias alabamae*)

We appreciate the opportunity to read the plan and to think about the particular problems encountered in protecting cave-limited species like the Alabama cave shrimp. The authors, Hartfield and Jacobson, have done an admirable job of establishing criteria and priorities for recovery in a species for which there is so little information. The ecology of cave organisms has largely been ignored in favor of studies of taxonomy, making the job of understanding the biology of this organism doubly difficult. We came across a recent book which may be helpful to the authors in their revision of the plan: *Adaptation and Speciation in Caves* by Culver, Kane and Fong (1996). The book addresses the evolution of various aspects of morphology, ecology and behavior in cave adapted animals by focusing on one well-studied amphipod. Several of the studies they cite may have information which could be used to estimate population parameters in the Alabama cave shrimp. More detailed comments follow:

I. Organization

In general, the plan would benefit from some reorganization. The connection between the background information and the criteria for recovery are never made explicit: Why all five caves? Why 20 years? One simple adjustment would be to make tables for some of the basic information about the populations in the three cave systems. Tables allow the reader to access information more quickly and clearly, and they leave space in the text for discussing implications. A table could also be used to represent the various risks to the populations in each cave. Another simple suggestion is to subdivide sections like "life history" and "reasons for listing" with additional subheadings.

A more substantial problem with the organization is that subsections of the plan should not only convey the details relevant to the heading (*e.g.* life history, reasons for listing, habitat), but also their relationship to the conservation of the shrimp. This will keep the plan more focused. For example, in the Life History section, what is the relevance of describing sexual dimorphism of the species? Instead, why not include the information about longevity and low reproductive rate described later, under the section about risks from collectors? The authors clearly understand a great deal about the hydrogeology of the caves as well as impending development in the recharge zones. But what aspects of hydrogeology are likely to be critical to the shrimp and why? Connecting the details of the biology of the shrimp to the characteristics of the habitat is crucial to justifying the recovery criteria and priorities.

II. Content

All of the information necessary to evaluate the objectives is present in the document, but due to some inconsistencies in wording, the reader is left uncertain of what exactly the objectives are. In the Executive Summary, the recovery objective listed is "Downlisting to threatened," Later, in the Recovery section, downlisting or "reclassification" is a secondary objective with protection of extant populations as the primary objective. The authors then state that reclassification is unlikely to be achieved under the stated criteria. This makes explicit justification of the recovery criteria (see above) all the more critical. In this same vein, if the objective of reclassification is to be met, a viable shrimp population must be restored to Shelta Cave. However, a number of questions must be answered before it is known whether restoration in Shelta Cave is even possible: Will modification of the gate actually lead to the return of the bats? Will this actually lead to the return of the shrimp? What about the water pollution detected in the cave? If the ban on the chemicals mentioned is effective, how long will it take those pollutants present to dissipate? What effect do they have on the shrimp? By making recovery of the shrimp in Shelta Cave a necessary condition for downlisting, the authors have given it an importance that outstrips its ranking in their prioritiesl. Perhaps a conditional statement should be built into the criteria; *e.g.* if new populations are found and recovery occurs in all other caves mentioned in the plan, then downlisting could still occur. However, we do agree with the authors that the measures suggested for restoring the shrimp to Shelta Cave should still be attempted since it is known to have had high numbers of shrimp historically.

III. Methodology

The authors describe clearly the difficulty of obtaining accurate information about numbers of shrimp, but it would be helpful to have a short description of the methods typically used to monitor the cave shrimp populations. This should be mentioned again under objective 3.0 in the Recovery section. Monitoring methods should be standardized across caves as much as possible so that the information obtained will be comparable. In addition, we feel that greater emphasis should be placed on monitoring and scientific investigation overall. Without basic demographic information, the effects of conservation measures cannot be assessed, nor can effective prognoses for the persistence of the population be made. Mark/recapture methods are used in monitoring studies for all sorts of animals. In a species which is so difficult to detect and to study, the authors should consider attempting to use mark/recapture to estimate population size, especially in Bobcat Cave.

Clarifying the sampling methodology will also remove confusion over the numbers of shrimp found in the various caves as presented on page 6. Where does the total number of shrimp found in Bobcat Cave come from? When the authors say that 172 shrimp were found during a series of 30 weekly visits, does this mean that 172 *different* shrimp were encountered? Or is this simply a total of the number of shrimp encountered on each visit? If so, a better way to report the data might be to show a table (as mentioned above) the mean and variance or perhaps the range in the number of shrimp encountered per visit per cave. The sampling methods used in each study or in each cave could also be included in the table (as mentioned above), making the information easy to access and compare.

IV. A couple other detailed comments:

1. Define the terms 'groundwater basin', 'cave', and 'cave system' or perhaps use just one of these terms consistently throughout. For example, in the Executive Summary section,

'groundwater basin' is used and again in the Recovery section, but between these sections, the document tends to refer to caves.
2. On page 2 it would be helpful if the specific caves were labeled on the map.

IV. Future Ideas

We have a couple of ideas for future work which could lead to more informed manangement practices:

1. A helpful way to look scientifically at the chances for survival and recovery of the Alabama Cave Shrimp populations would be to take the data from monitoring programs and create some demographic models for the population. Several programs are in existence (such as RAMAS and VORTEX) which can aid in studying stochastic variation in a population given some baseline data. Having some concrete numbers will help to verify the 20 year persistence mandated for the species. We have included some references from the book *Adaptation and Speciation in Caves* which may contain information about other cave-limited species which could be used to estimate parameters in a model of Alabama cave shrimp populations.

2. It would also be interesting to look at the genetics of cave shrimp populations. Due to technological advances like polymerase chain reaction (PCR), genetic sampling not longer has to involve the sacrifice of whole individuals. Some techniques involving the use of microsatellite DNA require only a very small amount of tissue or blood. Sampling just a few individuals from each cave would give a firsthand estimate of the degree of genetic divergence of caves from different cave systems versus caves within a cave system. Perhaps having a better understanding of gene flow in this species will allow future management plans to attempt reintroduction or assess the impact of changes in one cave on changes in other caves. The field of conservation genetics is rapidly growing and provides new tools for assessing the health of populations.

In summary, we feel that scientific research on the Alabama cave shrimp should be encouraged rather than discouraged. While rapid action to protect the shrimp is clearly necessary, long term managment objectives will be better achieved with more information. Thank you again for the opportunity to read and review this plan.

L. Hannah Gould
Paige Warren

DEPARTMENT OF THE ARMY
UNITED STATES ARMY MISSILE COMMAND
REDSTONE ARSENAL, ALABAMA
35898-5300

NOV 15 1996

REPLY TO
ATTENTION OF

Directorate of Environmental
Management and Planning

NOV 21 1996

Mr. Robert Bowker
Field Supervisor
U.S. Fish and Wildlife Service
6578 Dogwood View Parkway, Suite A
Jackson, Mississippi 39231

Dear Mr. Bowker:

We have reviewed the U.S. Fish and Wildlife Service's Technical/Agency Draft Recovery Plan for the Alabama Cave Shrimp (Palaemonias alabamae), September 1996, and provide the following comments for your consideration.

General Comments.

a. In general, the plan is well written and appears to address all the issues surrounding species protection and recovery. Everyone seems to agree that this species will be difficult at best to protect and manage due to the lack of knowledge of its life history, population ecology and habitat requirements. The real key to protection of existing populations is protecting groundwater quality in habitats of the known populations. Everyone agrees that this will be a monumental task with the difficulty in discerning the hydrology of extant population habitats given the Karst geology of the areas.

b. Page 16 of the draft provides a synopsis of sorts on the most current studies on cave shrimp habitats and populations, and indicates that the Army is funding Dr. Campbell's current work. We also point out that the Army has funded all the Geological Survey of Alabama work cited in the recovery plan either directly or through the Fish and Wildlife Service. We realize that it is not the purpose of this recovery plan to assign funding responsibilities, however, Geological Survey of Alabama is listed as the sole responsible agency under tasks 2.1 and 2.2 in the Implementation Schedule on page 28. We recommend that you consider how these tasks will be funded unless Geological Survey of Alabama will provide its own funding.

Specific Comments.

a. Executive Summary, Recovery Criteria 1. Alabama Cave Shrimp is known from only three groundwater basins. Hering, Glover and Brazelton caves are all directly connected hydrologically.

b. Executive Summary, Recovery Criteria 2. Due to the direct hydrological connections between Hering, Glover and Brazelton Caves, we believe that all individuals reported should be considered from a single population.

c. Executive Summary, Paragraph 6. The Army has already spent $280,000 over the past 8 years on the existing research and monitoring efforts toward Alabama Cave Shrimp for protection and management planning. Further, it appears that the cost estimates for some items in the recovery plan are low.

d. Page 8, Paragraph 2. Bobcat Cave is not within Huntsville City limits.

e. Page 17, Paragraph 2. Alabama Cave Shrimp is known from three groundwater basins as discussed above.

f. Page 28, Implementation Schedule Tasks 2.1 and 2.2. Who will be responsible for funding these tasks.

We appreciate the opportunity to provide comments on this Technical/Agency Draft Recovery Plan for the Alabama Cave Shrimp. Should you have any questions or wish to further discuss our comments, please contact Mr. Danny Dunn, Directorate of Environmental Management and Planning, 205-955-6970.

Sincerely,

for Jerry M. Hubbard
Director, Directorate of
Environmental Management
and Planning

3123 Searcy Dr.
Huntsville, Alabama 35810
February 21,1997

MAR - 3 1997

Theresa R. Jacobson
U.S. Fish and Wildlife Service
Jackson, Mississippi

Dear Theresa,

I'm really must apologize for the late response to your Draft Recovery Plan for the Alabama Cave Shrimp. Unfortunately I started a new job last Fall and I'm still running to catch-up to it and get into a regular routine so that it doesn't eat up my free time. Also this time of the year is the busiest time of the year for me to guide Boy Scout troops on caving trips. Anyway please forgive the slow response and I'll try to better next time.

I have reviewed the draft recovery plan and I have noted one statement that needs to be changed or modified. On page 11, "The entrance gate was modified in 1981 in an attempt to accommodate bats; however, no bats are known to have returned to the cave." Information from a local caver who has volunteered for several scientific cave research projects states of his observation of bats flying in and around the new gate door. I have enclosed an article he wrote concerning the observations at Shelta Cave. If you want to talk to him you can reach John French at (205) 881-0419 or his address is 10101 Westleigh Dr. Huntsville, Al. 35803.

I also wanted to bring you and Paul Hartfield up to speed as to what some of us here in Huntsville are up to involving Shelta Cave. After numerous letters and phone conversations with the NSS Conservation Chairman we have devised a plan of action in accordance to the draft recovery plan. We have started the process of getting permission toward rebuilding the gate at the cave entrance and seeking additional funding sources for research in advance of the gate building project. Already the Huntsville Grotto has donated $200 and request for funding from the NSS and the Bat Conservancy has met with favorable response. Our immediate plan is to observe the entrance for any bats flying in and out of the cave this April and May plus establish a weather (temperature, humidity, etc.) monitoring station inside and outside the cave. Once permission is granted (a long process) then we believe we can get the NSS to submit a proposal to U.S.F.W.S. to monitor water quality and re-gating the entrance. However this is still a long ways off and there are many obstacles.

This should bring you up to speed as to what we're planning on doing. If you have any suggestions please feel free to call or write. We're new at this so it kinda like walking through mud.

Sincerely,
Randall Blackwood
Randall Blackwood
(205) 859-3246